ECOSTRUCTURAL STUDIES ON THE NASAL ORGANS OF SOME TELEOSTS

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BY

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CERTIFICATE

I certify that "Ecostructural studies on the nasal organs of some teleosts" is the original work of Mr. Intisar Anees Siddiqui and has been carried out under my supervision. He is permitted to submit the work in the partial fulfilment for the degree of Master of Philosophy in Zoology of the Aligarh Muslim University, Aligarh.

(Sardar Mahmood Khan)
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CONTENTS

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(Intisar Anees Siddiqui)

I N T R O D U C T I O N

INTRODUCTION

Irritability is the universal property of life which manifests as responsiveness to the changes in the environment of the organism. The response is the change in the organism or part of it produced by the stimulus from environment which may be favorable or unfavorable. The net response of an animal to a variety of biotic and abiotic stimuli in a given environment is known as animal behaviour.

There must be a chemical or neurosensory co-ordination between the animal and its external environment for successful survival. Neurosensory system is a mechanism to co-ordinate various activities of an animal. In other words, it is a kind of channel between stimulus and the response which can be illustrated as follows:

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         Receptor INFORMATION          ORDER  Effector
Stimuli- Organ -- ----------- C.N.S.   -----  Organ   ---Responses
                  sensory              motor
                  nerve                nerve

I---------SENSATION---------I  I-------RESPONSE---------I
```

Sense organs contain specialized nerve cells which conduct impulses and the responses are determined according to the intensity and nature of the stimulus.

Receptors for the sense of smell consist of individual bipolar neurons derived from the thickened area in the superficial ectoderm. In aquatic vertebrates these are confined to the olfactory epithelium, lining the olfactory sacs. The olfactory sacs are nothing more than blind invaginations of outer epithelium. Chemical substances must be in solution before they can stimulate the moist mucus covered olfactory epithelium (Weichert, 1965).

According to Kluge(1977), olfaction has a significant role in many behavioral patterns. In fishes, olfactory cues help maintain their aquatic life as they detect the quality of water they inhabit. Many fish utilize olfactory cues:

-to maintain contact in their territory in their school,
-to sense enemies and to trigger appropriate escape reaction,
-to detect food and prey and
-to recognize dominant and submissive members of their social commumity.

The olfactory organ of fish serves as a sensory input that can aid in detecting food and prey (Parker,1922), recognizing relatives (Nordeng, 1971) and discovering danger (Frisch, 1941).

Verious workers have investigated and observed the piscine olfactory organs for their structure and function. However, very little information is available regarding the ecological adaptation in these organs.

The olfactory organs of fishes are diversely developed.At one extreme there are macrosmatic forms such as elasmobranchs and most of the eels, at the other there are microsmatic species (e.g. Pike, flying fish, feather-back, life fishes, angler fishes). In most species of lung fishes, the development of olfactory organ lies in between these two extremes.

The variations in the anatomy of the olfactory organs have led to attempts to classify fishes according to olfactory organs (Pipping, 1926) or correlating the habitat of the fishes with their nasal structures (Faure, 1944).

A comparison between the olfactory organs of different cyclostomes and fishes shows on one hand, a common structural ground plan and evolution from certain basic types but on the other hand, it also shows a great variation in detailed structure. Such variation may be the result of ecological adaptation. This means that a species from a certain ecological niche or habitat has olfactory organs which are adapted or are adapting to serve that kind of life (Bertmar, 1969).

For the present work two fishes namely *Catla catla* (Hamilton) belonging to femily Cyprinidae and *Clarias batrachus* (Linnaeus) of family Clariidae were selected which are known to inhabit different niche in the similar bodies of freshwater.

Catla catla is a planktivorous carp which lives in a clear surface water. It feeds preferably on rotifers, cladocerons and copepods (Kamal, 1964). Its lips are fleshy and are known to possess taste-buds. The other fish *Clarias batrachus* differs from the former fish in being a bottom dweller and carnivorous in food habit. This catfish subsists on insect larvae, shrimps, worms, fish and organic debris found on pond bottom (Jhingran, 1975). Being an air-breathing form it can also survive in oxygen-deficient water. A number of barbels on its snout are known to have numerous sensory cells widely distributed all over the surface.

It was decided to see if these two fishes having different modes of life show any adaptive modification in the structure of their olfactory organs which could be related to the conditions obtained in the ecological niche they occupy. Further it was also to be seen whether the form,location and openings of the nasal chamber, presence or absence of accessory nasal sac and histological characteristics of the olfactory lamellae have any ralationship with their feeding habits.

From the data thus collected, it would be possible to analyse the relationship between the olfactory and visual faculties of the two fishes and would also furnish material for a comparative study.

The text is illustrated with a number of figures and microphotographs.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The literature on the piscine nasal organs has been in existance for a little more than a century. The earlier accounts though brief but nevertheless pioneering have been reported by Burne(1909). Sophie Pereyaslawzaff (1876; quoted by Burne, 1909) reported the anatomy of olfactory organs in two fishes viz. *Solea impar* and *Lophius piscatorius*. In 1884, Blaue published his work on olfactory membranes in fishes and amphibians. He described anatomy of olfactory pit and rosette of *Belone*, *Exocoetus*, *Trigla*, *Esox*, *Umbra*, *Cottus*, *Gobius* and *Gadus*. Wiedersheim (1887; quoted by Burne, 1909) later gave an account of degeneration of olfactory organ of plectognaths, describing a series of stages in *Tetrodon nigropunctatus*, *T. immaculatus*, *T. papua*, *T. pardalis*, *Diodon maculatus*. Bateson(1889) reported tubular characterstic of anterior nostril in a few fishes who seek their food by scent. Such fishes are *Conger*, *Anguilla*, *Lepadogaster*, *Solea* etc. In *Conger*, this tube is simple straight and well developed which proceeds beyond the surface of the nose. The tube consists of two flaps of skin in eels while in the rocklings it takes the form of a very short tube whose dorsal edge is produced into a long barbel. The anterior nostril of loaches and *Lepadogaster* resembles that of rockling but stands up more vertically from the head and posterior edge of the aperture is not produced into the barbel but it is bent over to form a kind of hood.

Bateson(1889) differentiated four types of olfactory folds (Lamellae) on the basis of the arrangement of plates:

(i) in skates and dog fish, the plates are arranged in a radiating manner like septa of an orange;

(ii) in Conger and eel, the plates are arranged in two rows on each side of the central raphe;

(iii) the third type is most commonly found in fishes where lamellae are arranged in a radiating manner, forming a convex eminence in the olfactory chamber;

(iv) in the species of Pleuronectes and in Hippoglossus vulgaris, the lamellae are arranged in a single row lying parallel to the long axis of the body.

Burne(1909) has classified the rosette, nostril and nasal sac in different types on the basis of morphological characters. He distinguished three types of olfactory rosette: oval (in most fishes), round (in Esox) and elongated (in eels). Species with round rosettes normally bear only a few lamellae and usually show less developed olfactory sense (microsmatic); Fishes with elongated rosette normally have large number of lamellae and show well developed sense of olfaction (macrosmatic). Intermediate between these two types are the fishes which possess oval rosettes.

According to Burne(1909), the variation in shape and relative size of the olfactory chamber is comparatively little and their position with regard to the bones is constant and fixed. He (1909) also reported that the most variable part of the olfactory organ are perhaps the nostrils but their variablity has least correlation with the natural affinity of fishes. Burne(1909) identified four different types of anterior nostril, namely:

(a) simple perforation; (b) tubular; (c) with posterior hood and (d) with internal curtain.

Likewise, the posterior opening was reported to be of two types.

(a) a simple open perforation flushed with the surface of the skin of the head and

(b) a slit or pin-hole guarded by valves, the outline being circular, oval or crescentic.

The accessory nasal sacs in fishes were put by Burne (1909) into three groups:

(1) a single sac directed anteriorly from either above or below the rosette,

(2) a single sac diredted posteriorly towards the orbit.

(3) two sacs: ethmoidal and the lacrymal.

Allis(1916) gave a fairly detailed account of lips and nasal apertures in gnathostome fishes. In teleosts, he reported the shifting of two nasal openings from ventral surface in the embryos to the dorsal surface in adults. He also compared the nasal apertures with other groups of fishes.

Teichmann(1954) classified on the basis of relative development of optic and olfactory faculties and distinguished three main groups: eye-nose fishes with equally developed optic and olfactory faculties (*Phoxinus* and *Gobio*); eye-fishes with a predominantly developed optic faculty (*Esox* and *Gastrosteus*) and nose-fishes with a predominantly developed olfactory faculty (*Anquilla* and *Lota*).

Marshall(1967) reported that the olfactory apparatus in some bathypelagic fishes shows specific sexual dimorphism, as it is better developed in males whereas regressed and small in females. He observed that males of *Cyclothone* spp., ceratioid angler fishes have better developed olfactory organs as compared to those of females. Both sexes of *Lyomeri*, *Avocettina* and *Cyema* are microsmatic.

Considerable amount of work has been done on the morphology of Indian teleosts. Bhargava(1959) studied the development of nasal organs of two species of *Mastacembelus*, *M. armatus* and *M. pancalus* and *Rhynchobdella aculeata* and reported that water current enters through the anterior tubular nostril and passes out through the posterior, maintaining a constant flow of water through the nasal organ.

He further reported the infranasal chamber and described it as a reservoir which helps in keeping the posterior nostril open in muddy water. In 1962, Bhargava described tubular and folded type of olfactory saccule in family Mastacembelidae.

The anatomy of some Indian teleosts(Muraena undulata, Channa punctatus, Cynoglossus oligolepis, Garra gotyla, Wallago attu, Glyptothorax telchitta, Labeo rohita, Sisor rabdophorus) have been described by Kapoor and Ojha (1972, 1973 a, 1973 b) and Ojha and Kapoor (1971, 1972, 1973 a, 1973 b, 1974).

Devitsyna (1972) studied the olfactory apparatus of the white sea cod (Gadus morhua marisalbi), the navaga (Eleginus navaga) and burbot (Lota lota). He compared two marine species with freshwater member of family Gadidae, the burbot. The result enables us to assess the extent of development of the organ of olfaction in each of these species and to detect a number of adaptations in the olfactory receptors associated with the ecological characteristics of the species.

Since the first description by Schultze (1956), it has been recognized that the olfactory epithelium in vertebrates consists of three cell types: receptor cells, supporting cells and basal cells.

In some species (*Anguilla*, *Myxocephalus* etc.), large flask like mucous cells are interspersed among supporting cells (Holl, 1965; quoted by Sharma, 1981). He (1965) further distinguished three types of arrangement of sensory epithelium in the lamellae:

(i) continuous sensory area except for the dorsal part of lamellae (*Ictalurus*, *Anguilla*, *Perca*, *Salmo* etc.);

(ii) separated in large areas between the lamellae (*Esox*) and

(iii) dispersed in small islets. (*Phoxinus*, *Cyprinus*, *Carassius* etc.).

The individual olfactory cells of fishes are similar to those of other vertebrates in general appearance though there is great variation even within a particular olfactory organ.

Shahab *et al.* (1981) gave a fairly detailed account of the anatomy of the olfactory organs of *Rita rita*. They also observed **unidirectional flow** of water. They reported an interesting feature of *Rita rita* that in spite of being mostly a botton dweller, semisedentary fish it is devoid of accessory olfactory sacs. They also gave a brief note on the habit and habitat of the fish studied.

Rahmani and Khan(1981) presented a resume of their studies on the functional morphology and histology of olfactory organs in a number of teleosts.

In the recent years, references are available on various aspects of fish olfactory organs. Singh and Singh (1984) described the ecomorphology of olfactory organs of hill stream catfish, *Glyptothorax pectinopterus*. They found that olfactory organs of *G. pectinopterus* are in conformity with its ecological habitat and concluded that the sense of smell becomes more important to the fish than that of vision.

Waghray(1984) reported the sexual dimorphism of the olfactory organ alongwith its morphology and histology in *Narcine timlei*.

Ridet and Bauchot (1984) highlighted the importance of olfaction in teleosts and determined the extent of development of the olfaction through isoponderal indices of olfactory bulbs in teleostean fishes. They found a correlation between ecological and biological adaptations and no correlation between evolutive levels and the importance of olfaction.

Ahmad and Siddiqui (1986) have very recently described the morphology of nasal organs of *Barbus apogon* and reported the fish as an eye-nose fish.

MATERIALS AND METHODS

MATERIALS AND METHODS

For present investigations, live specimens of *Catla catla* were procured from a composite fish farm near Aligarh, while those of *Clarias batrachus* were purchased from the local fish market as they are available in plenty.

To study the position of the nasal chamber in relation to the skull bones, the dried skulls were prepared by keeping fish skulls in 4% KOH solution for adequate time after dressing and skinning. The muscles were cleared off with forceps and brush. Clearing and bleaching was done by hydrogen peroxide solution. Finally the treated skulls were dried in sun.

For morphological studies, the adult fishes were fixed in 10% formaldehyde solution and stored at 4°C to avoid shrinkage. A sufficient number of fishes of varying lengths were selected to obtain the normally available size range. Sterioscopic binocular microscope was used for the study of architectural pattern of nasal organs and their relationship with the brain. Diagrams were drawn with the help of camera lucida and the oculo-micrometer was used for the microscopic measurements.

The dissected olfactory rosettes were kept in 70% alcohol before the separation of lamellae. This allowed easy separation of the lamellae from the raphe and the floor of the nasal chamber. To separate individual lamella, each lamella was cut at the proximal end and then on the floor with a sharp edged blade.

For histological studies, the entire heads of the two fishes were fixed in alcoholic Bouin's fluid for 20-24 hours. The fixed tissues were carried for hydration through the descending series of alcohol upto 30% and then several washes in distilled water were given to remove picric acid completely. This material was then dehydrated by ascending series of alcohol with the usual grades. The material was treated for clearing, first with the mixture of absolute alcohol and xylene and then with pure xylene for two hours.

The dehydrated material was put for paraffin embedding. For embedding, the dehydrated material was put in a mixture of xylene and molten paraffin wax (M.P. 60-62°C) in a thermostat oven regulated at 65°C for half an hour before keeping in pure molten paraffin wax. Finally , the blocks were prepared in pure wax. After trimming the blocks, sections of 4-7 μm were cut with a rotary microtome. The sections were dried for sufficient time after stretching. During trials with different stains, Elhrich's haematoxylin counterstained with alcoholic eosin was found satisfactory. Stained sections were mounted with DPX mountant. Photomicrographs were taken on Olympus BH 2/C-35 AD-4 photomicrographic system.

O B S E R V A T I O N S

OBSERVATIONS

A-1. Morphology of the nasal organs of *Catla catla*:

a) The nasal chamber and its openings:

Catla catla possesses a pair of nasal organs in the form of nasal chambers, each lying dorsolaterally in the middle region of the snout slightly above the level of the eyes(Fig. 1, 7, 8). Each chamber communicates with the exterior through two openings, an anterior and a posterior nasal opening situated at the two extremities of the chamber(Fig. 1,2,8,9,10).

The almost circular anterior nasal opening is bounded by a distinctly elevated circular rim whose posterior margin is continuous with the nasal hood(Figs.2,8,9,10). The large posterior opening is kidney-shaped and lies in a depression covering the posterior part of the chamber. Through this large opening the posterior part of the rosette is distinctly visible(Fig. 9,10). The two openings lie close to each other and are seprated by a thin integumental partition, the nasal hood.

The anteriorly directed nasal hood projects out from the general surface of the head. It extends deep downwards upto the upper concave surface of the rosette and this extension delimits an anterior and a posterior part of the nasal chamber. This inflected part of the nasal hood forms a curtain (Fig. 3) which prevents rapid outflow of the incoming water so that it may be thoroughly analyzed by the lamellae. The skin of the head is deeply pigmented but the lips of the anterior opening and the nasal hood are comparatively less dark (Fig.10).

b) <u>The nasal capsule</u>:-

The nasal chamber is encapsulated by different cranial bones. It is bounded on the dorsal side by the nasal, ethmoid and anterior margin of the frontal bones. The nasal also forms the boundary of the two openings. On the mesial side each chamber is bounded by lateral ethmoid. The posterio-ventral part of the chamber rests on an extension of the lateral ethmoid while the anterio-ventral part is supported by palatine. The anterior side of the nasal chamber is bounded by maxilla and premaxilla where as on its posterior side lies a small prefrontal. The nasal chamber remains connected with the surrounding bony nasal capsule through fibrous connective tissue.

c) <u>The olfactory rosette:-</u>

Each nasal chamber contains an oval, bowl-shaped olfactory rosette which occupies the entire chamber (Figs.4,11). The rosette has an outer concave and a mesial convex surface. The long axis of the rosette is slightly obliquely oriented with respect to the median axis of the fish body. From the margins of the short spindle-shaped raphe radiate a series of closely set lamellae. These are thick and crescentic in outline, connected to the raphe by their proximal ends. Their distal ends extend upto the wall of the nasal chamber while the convex mesial margin rests upon its floor. The olfactory lamellae are joined to the raphe at right angles in the middle region but asone proceeds towards the two ends, they gradually become more obliquely placed till they converge at the two ends.

Almost in middle of each lamella, there is a linguiform process (Fig. 4). These processes of the successive lamellae are so arranged serially that they collectively form a ridge which divides the concave side of the rosette into a central part and a peripheral channel (Figs. 4,11).

As regards the circulation of water in the rosette, it may be mentioned that the author has not undertaken any experiment on the live fishes to determine the course of the water current butthe morphological position of the two nasal openings, the position and direction of the hood alongwiththe structure of the rosette all lead to one inevitable conclusion that water enters through the opening that has been termed as anterior and flows out through the other opening. The location of the anterior aperture above the anterior part of the rosette, the nasal hood, the rim of anterior aperture and the curtain all are so situated that they form a barrel shaped passage which directs the water to spill over the lamellae of both the sides. After bathing the lamellae water passes out throgh the posterior opening.

d) <u>The anatomical relationship of the nasal organ and the brain</u> :-

After carefully removing the ethmoid, the nasal and the head muscles the anatomical relationship of the brain and the olfactory rosette becomes clearly evident (Figs. 6, 12).

As the nasal chambers become fully exposed on the lateral sides of the head, they appear large bowl-shaped structures containing a prominent rosette. From the posterior part of each nasal chamber, arises a short but thick olfactory nerve which soon after emergence through the olfactory foramen passes insensibly into the olfactory bulbs behind. The two olfactory bulbs are borne on long and thick olfactory tracts which run posteriorly to join the corresponding olfactory lobe of the brain, a little posterior to the level of the eyes.

e) The ecological coefficient :-

For ecological coefficient of the olfactory organs the olfactory and retinal areas were measured by Techmann's method. The surface of the olfactory lamellae in both the rosettes was found to be 267.24% of surface area of the two retinae of fish.

FIGURES (A - 1)

Fig.1- Lateral view of the head of _Catla catla_.

Fig.2- Surface view of the nasal chamber of _Catla ćatla_.

Fig.3- Nasal openings of _Catla catla_ from inner side of the nasal chamber.

Fig.4- Olfactory rosette of _Catla catla_.

Fig.5- A set of lamellae from the outer half of right rosette of _Catla catla_.

A.N.O.	:	anterior nasal opening
C.P.	:	central part of the rosette
E.	:	eye
Lm.	:	lamella
Lng.	:	linguiform process
N.H.	:	nasal hood
P.N.O.	:	posterior nasal opening
Per.Ch.	:	peripheral channel
Rm.	:	rim of the anterir opening
Rph.	:	raphe
Ctn.	:	curtain

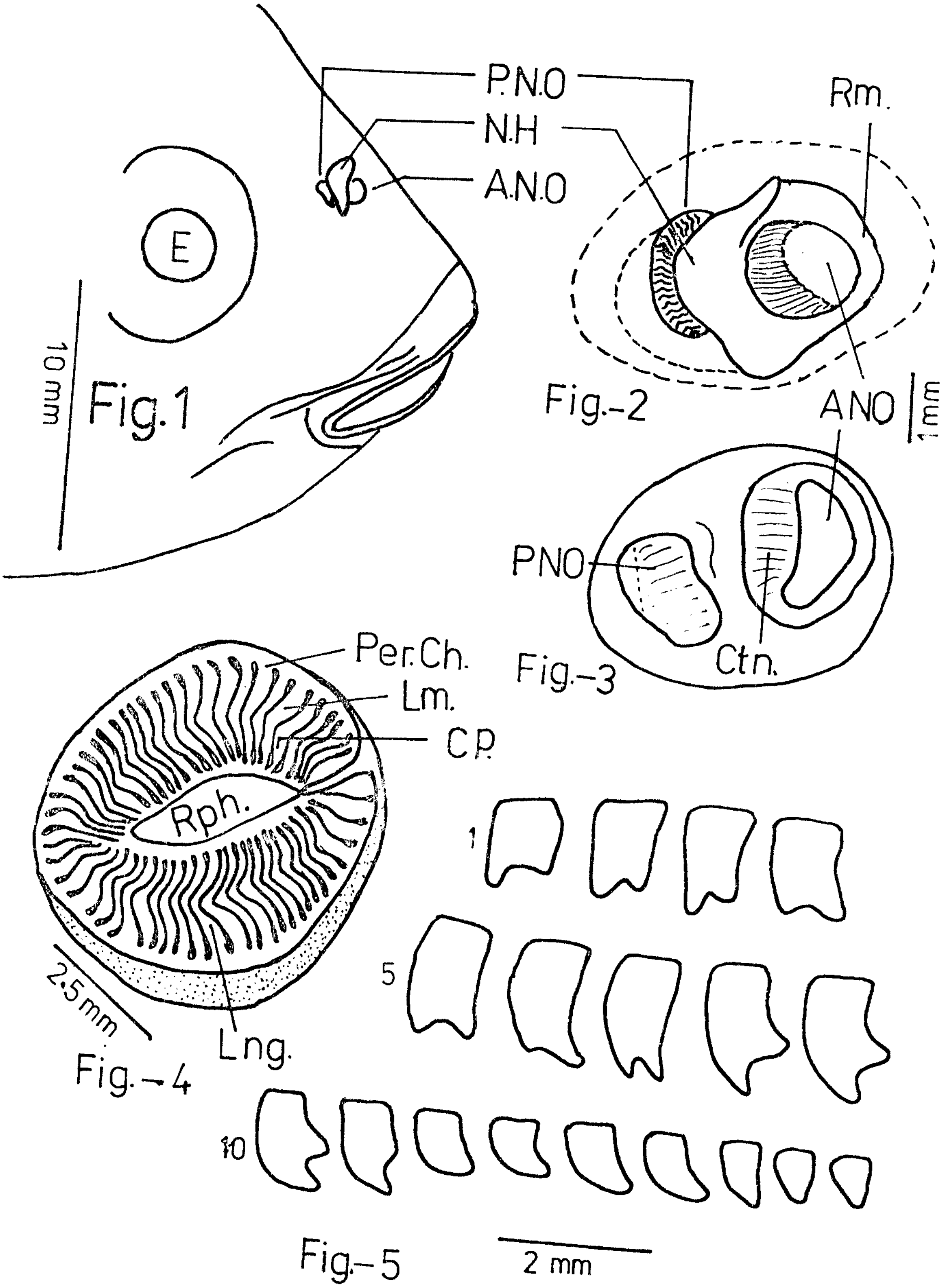


Fig.1

Fig.–2

Fig.–3

Fig.–4

Fig.–5

Fig.6- Dorsal view of the dissected head showing nasal organs in relation to the brain

Cbl.	:	cerebellum
E.	:	eye
O.B.	:	olfactory bulb
O.L.	:	olfactory lobe
Op.L.	:	optic lobe
Rst.	:	olfactory rosette

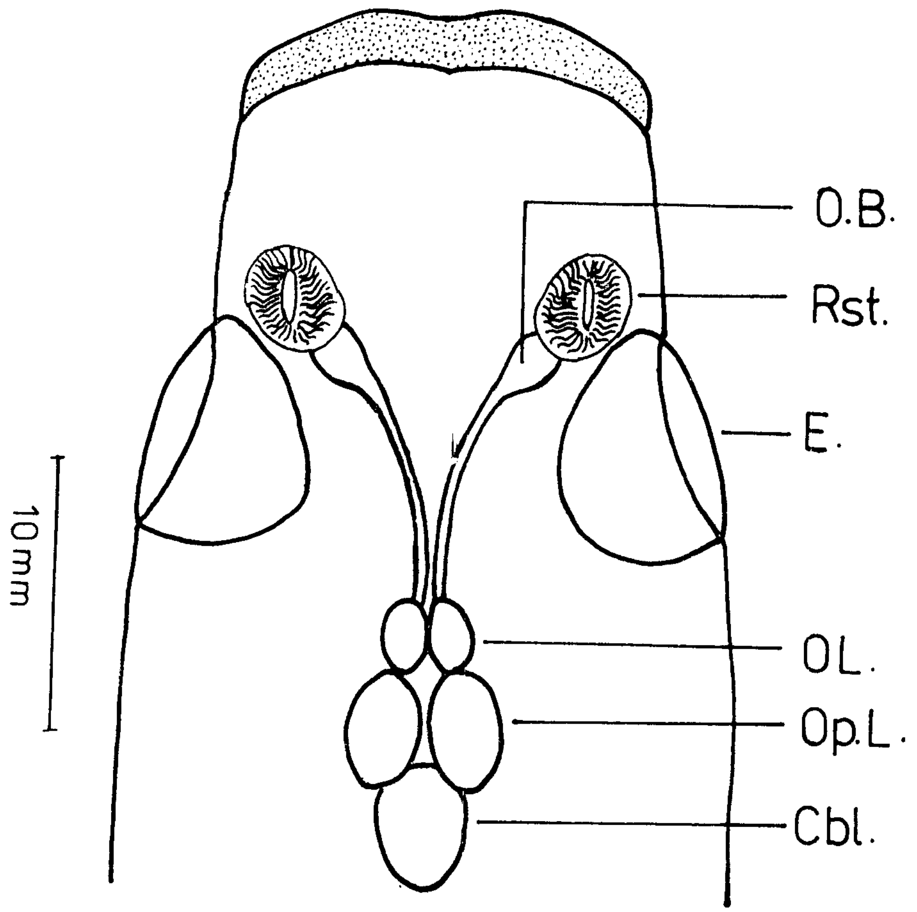


Fig. 6

Fig.7- Lateral view of _Catla catla_.

Fig.8- Lateral view of the head of _Catla catla_

A.n.O.	:	anterior nasal opening
E.	:	eye
N.H.	:	nasal hood
P.n.O.	:	posterior opening

Fig. 7

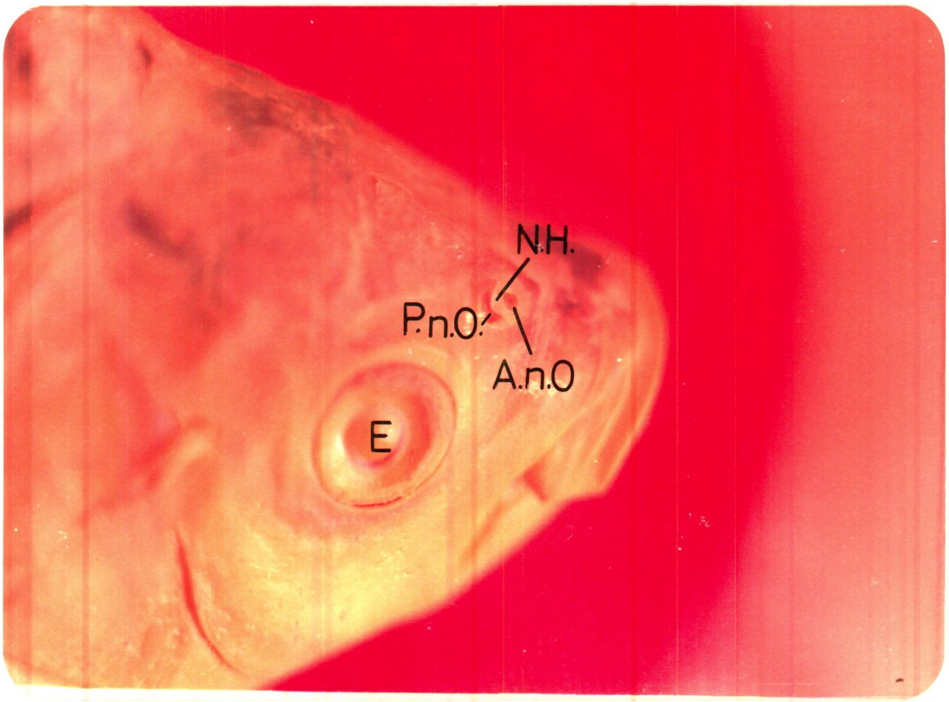


Fig. 8

Fig.9- Dorsolateral view of the anterior region of the head to show the position of the nasal chamber with reference to the eye

A.n.o.	:	anterior nasal opening
E.	:	eye
N.H.	:	nasal hood
P.n.o.	:	posterior nasal opening
Rst.	:	rosette

Fig.10- Close surface view of the right nasal chamber

A.n.O.	;	anterior nasal opening
N.H.	:	nasal hood
P.n.O.	:	posterior nasal opening
Rst.	:	rosette

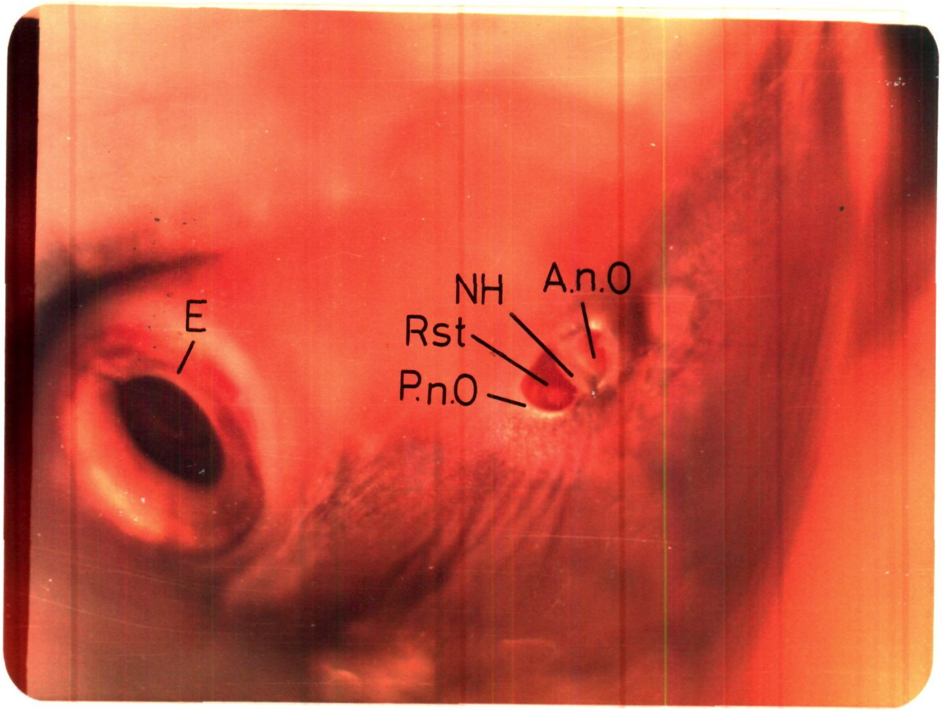


Fig. 9

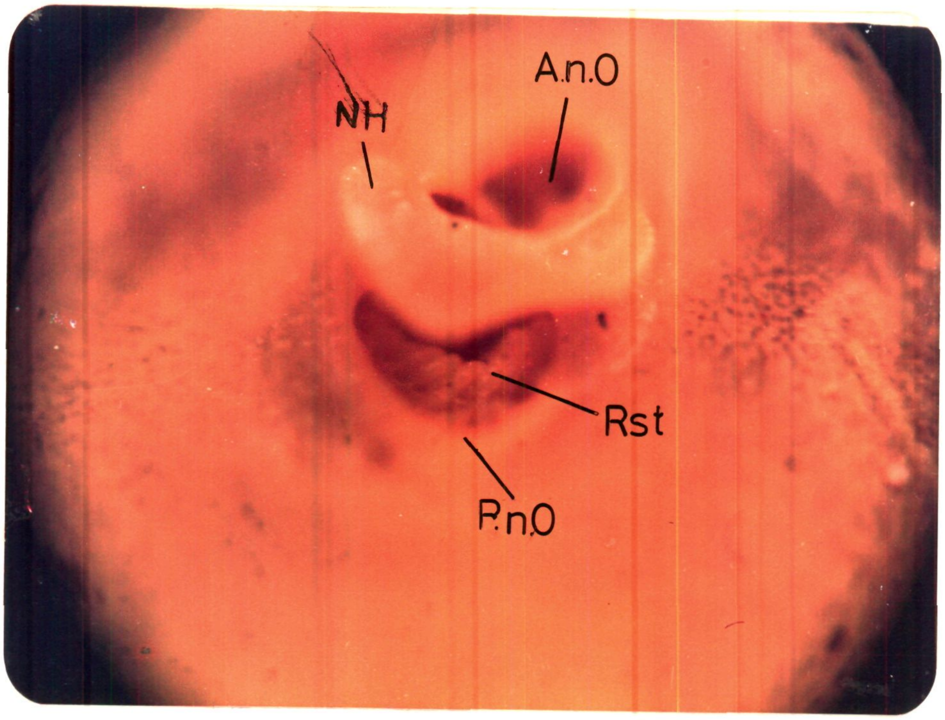


Fig. 10

Fig.11- Lateral view of the dissected snout with the exposed rosette

C.P. : central part

Lm. : lamellae

Rst. : rosette

Fig.12- Dorsal view of the dissected head showing the nasal organs and their connection with the brain

Clb. : cerebellum

E. : eye

O.B. : olfactory bulb

O.L. : olfactory lobes

Op.L. : optic lobe

O.T. : olfactory tract

Rst. : rosette

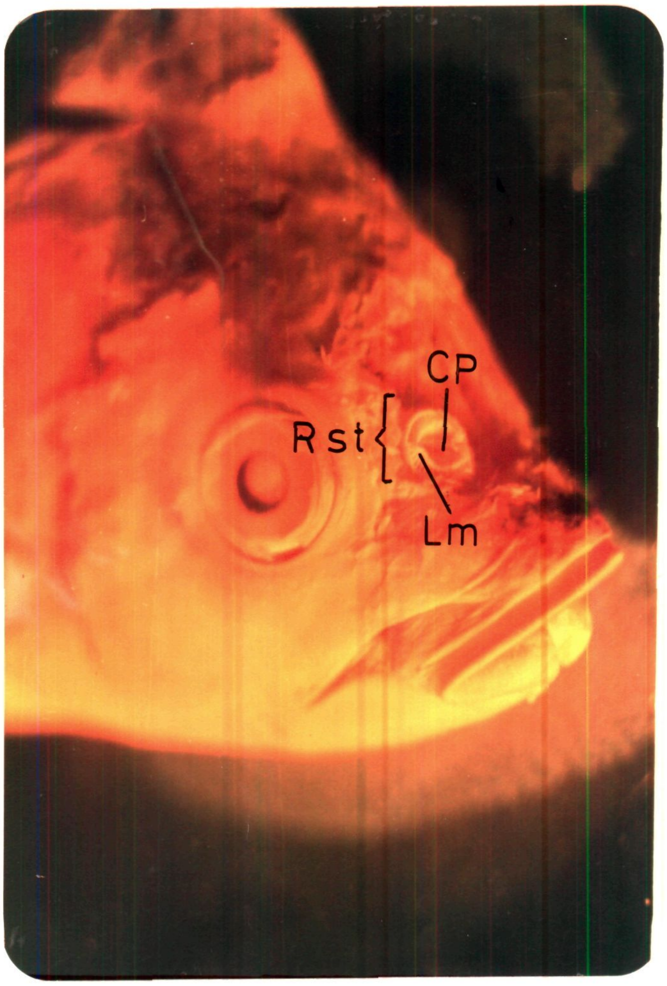


Fig. 11

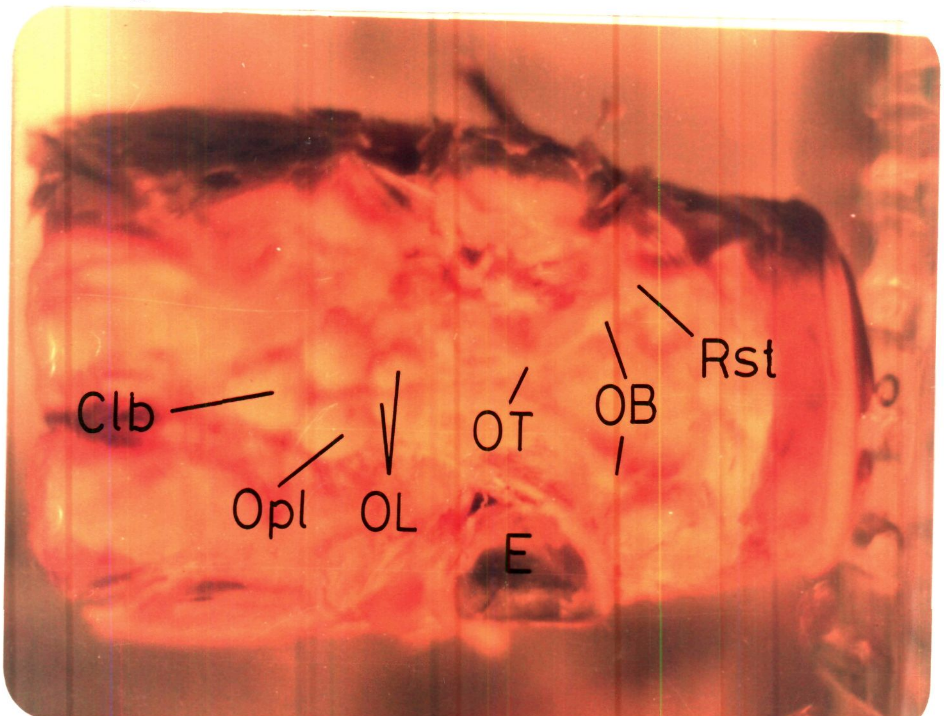


Fig.12

A-2. Histology of the nasal epithelium of *Catla catla*:

As mentioned earlier, the olfactory rosette of *Catla catla* comprises a large number of olfactory lamellae arranged serially on either side of the raphe. The entire ventral margin of each lamella is attached to the chamber wall while its proximal end joins the raphe. Dorsally the lamellae are free and are separated from each other by interlamellar spaces (Fig. 13).

In both the vertical and horizontal sections of the rosette two regions in a lamellae are histologically distinguishable. Each lamella consists of a central core called the sub-mucosa surrounded by a peripheral sensory epithelial layer -the mucosa (Figs. 16,17). A well defined basal membrane remains sandwitched between these two regions.

According to Windle(1976), the following cell types are found in the olfactory epithelium of the fishes. These have been carefully identified in the present sections and the same nomenclature has been retained as given below:

1. basal cells, 2. supporting cells, 3. receptor cells, 4. goblet cells.

These cells are arranged in the mucosa in such a way that two zones - the basal and supporting zones can be clearly seen.

<u>The basal zone</u>:-

Basal zone is narrow and is formed by closely set undifferentiated basal cells lying very close to the basal membrane (Figs. 18, 20, 21). They contain darkly stained oval nuclei. These cells are believed to give rise to supporting cells which finally form goblet cells whenever required. In the present sections at certain places in the basal zone the cells have been observed in various stages of mitosis (Fig. 20). These in due course are transformed into supporting cells (Fig. 21). The occurrence of basal cells is also noticed in the central core or the submucosa (Fig. 17).

<u>The supporting zone</u>:-

Following are the different cell types present in the supporting zone of the nasal epithelium of <u>Catla catla</u>:

a) supporting cells,

b) receptor cells and the

c) goblet cells.

a) The supporting cells:-

The supporting cells are tall, columnar epithelial cells and are of two types:

i) ciliated supporting cells and

ii) non-ciliated supporting cell.

The ciliated supporting cells are comparatively large and broad with a slightly convex distal end bearing the cilia which project into the interlamellar spaces. The distal end contains homogeneous cytoplasm while the proximal part is inconspicuous and difficult to trace among the other cellular components lying beneath (Figs. 19, 21). These cells bear oval or rounded nuclei (Figs, 17, 20). The dark staining nuclei of ciliated supporting cells are larger than those of the receptor cells. Cilia are delicate and fine projecting into the interlamellar spaces. These cells undergo a process of transformation into goblet cells. The transitional stages are seen in the olfactory mucosa of *C. catla* (Figs. 17, 20).

The non-ciliated supporting cells occupy a major part of the supporting zone in the olfactory epithelium of *C. catla*. They have elongated cell bodies with large oval nuclei (Figs. 18, 20). The outer or distal part of these cells is elongated which may extend upto the peripheral margin of the mucosa. These cells are transformed into mucus-secreting goblet cells which at places form the lining of the lamella with a few intervening supporting cells (Fig. 21).

b) <u>The receptor cells:</u>-

The receptor cells in the nasal mucosa of *C. catla* though fewer in number are spread all over the surface. The olfactory receptor cells can be identified as primary neurons, spindle-shaped receptors and rod-shaped receptors (Figs. 18, 19, 20, 21).

The primary neurons are located close to the basal membrane and their dendrites are dark staining (Fig. 18). The axons of these neurons are short and difficult to identify. The nucleus of primary neurons is oval in shape.

The spindle-shaped receptors have long dendrites and considerably long axonal ends (Figs. 18, 19). The nuclei are oval. These cells are rarely seen in the epithelium and are not present among the marginal goblet cells.

The rod-shaped receptors have thickened elongated dendrites which extend inbetween the two goblet cellls or may singly pass through the theca of an empty goblet cell. The dendrites have a distally expanded tip which bears minute cilia. The nucleus of these cells is darkly stained and elongated. The axons extend upto the basal zone.

c) The goblet cells:-

Goblet cells lie generally at the peripheral surface of the mucosa. Their distribution is ununiform being interspersed among the supporting cells. These cells are oval in shape and appear swollen due to mucin (Fig. 21). The neck in the goblet cells is absent and therefore the main body lies on the free surface of the lamella. These cells have small nuclei embedded in a samll island of cytoplasm at the bottom. Basally, the goblet cells are renewed by the process of cellular transition from the basal cells. However some goblet cells may also be formed from supporting cells but basal cells constitute the principal source.

The sub-mucosa and raphe:-

The cellular composition of the sub-mucosa and the raphe is almost similar. There is a ground tissue in the form of an elastic connective tissue. A number of branched fibroblasts histoblasts, histocytes and basal cells are also present (Figs. 15, 17).

FIGURES (A-2)

Fig.13- Horizontal section of the olfactory rosette of *Catla catla* showing the arrangement of lamellae X 25

Fig. 14- Vertical section of the olfactory rosette of *Catla catla* X400

D.L.	:	distal end of lamella
F.N.C.	:	floor of the nasal chamber
I.L.S.	:	inter lamellar space
Lm.	:	lamella
Mc.	:	mucosa
P.E.	:	proximal end of the lamella
Rph.	:	raphe
S.Mc.	:	sub mucosa
W.N.C.	:	wallof the nasal chamber

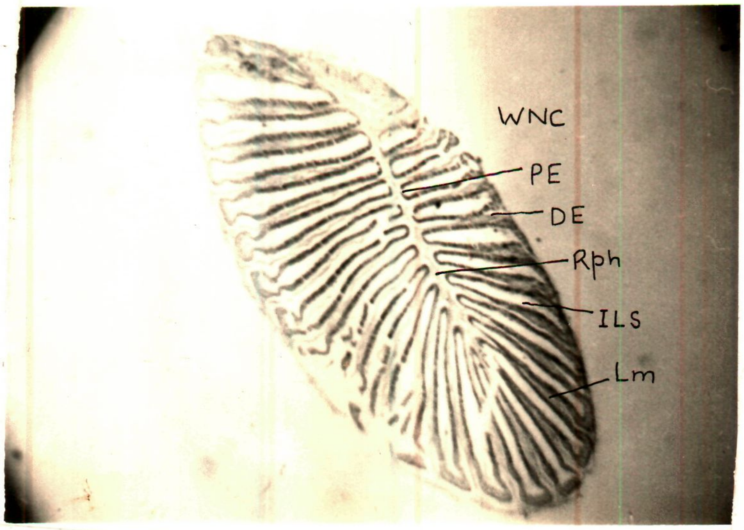


Fig.13

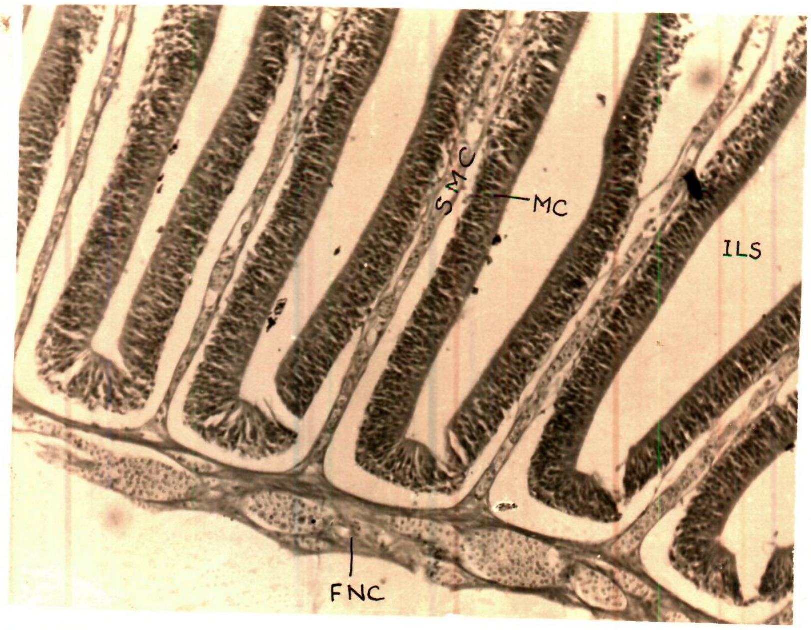


Fig.14

Fig.15- Horizontal section of the rosette of *Catla catla* X400

Fig.16- Vertical section of the rosette of *Catla catla* showing two lamellae with an inter-lamellar space inbetween X400

B.M.	:	basal membrane
I.L.S.	:	interlamellar space
M.	:	mucus
Mc.	:	mucosa
Rph.	:	raphe
S.Mc.	:	sub mucosa

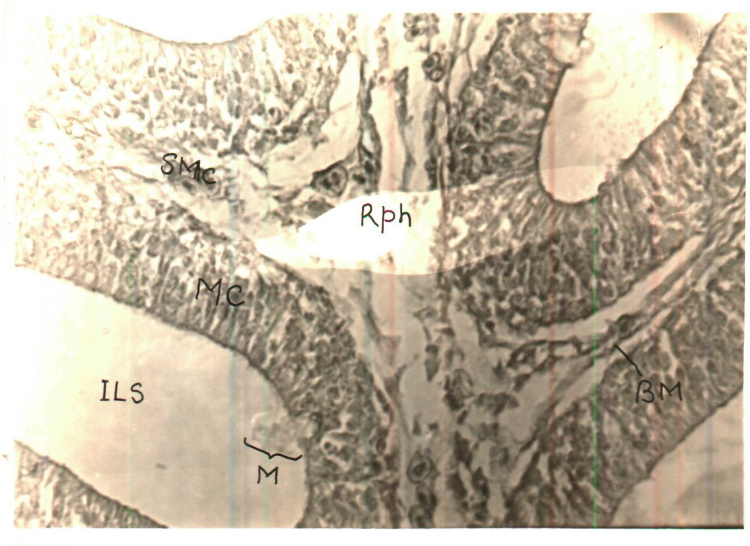


Fig. 15

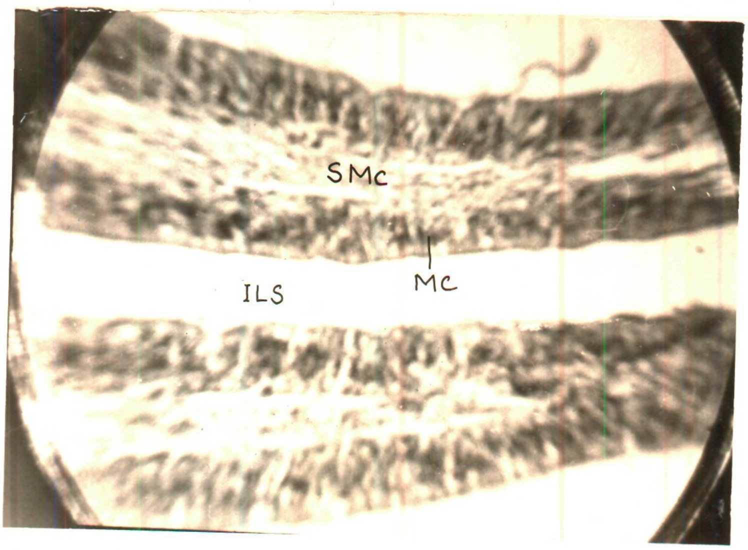


Fig. 16

Fig.17- Vertical section of an olfactory lamella of *Catla catla* showing different cell types X400

Fig. 18- Vertical section of the olfactory lamella of *Catla catla* swoing details of the cell types X1000

B.C.	:	basal cells
B.M.	:	basal membrane
B.Z.	:	basal zone
C.S.C.	:	ciliated supporting cells
Mc.	:	mucosa
N.S.C.		non-ciliated supporting cells
R.R.	:	rod shaped receptors
S.Mc.	:	sub-mucosa
S.Z.	:	supporting zone
T.S.C	:	transitionary supporting cell

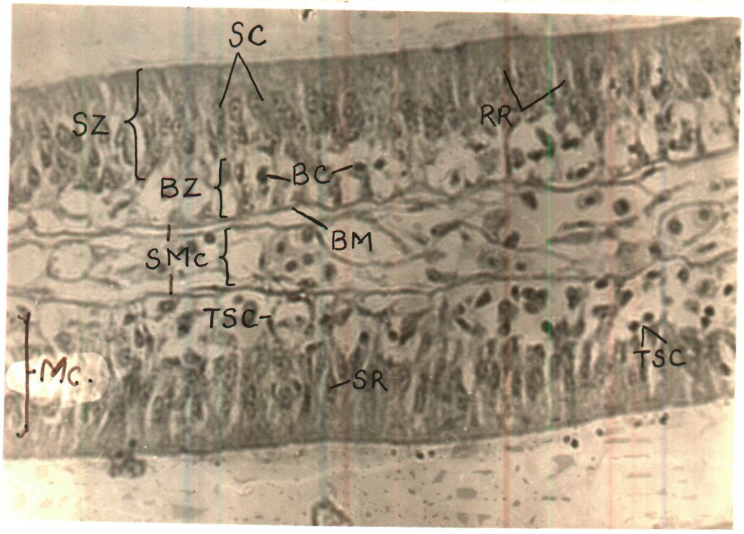


Fig. 17

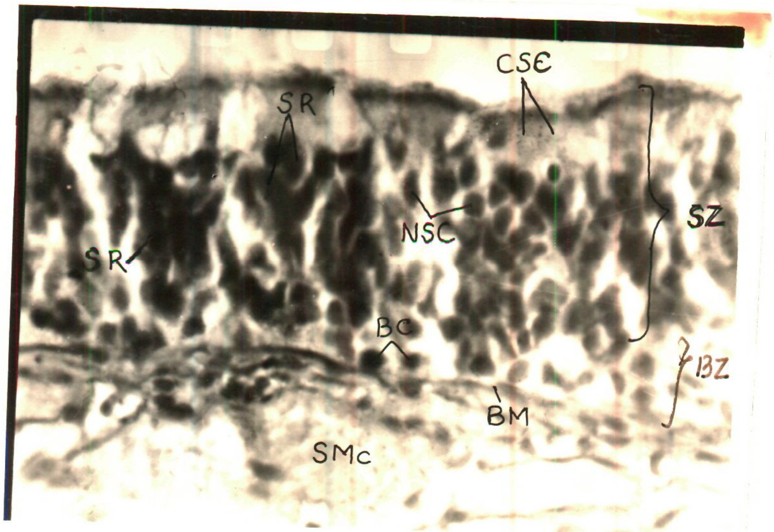


Fig. 18

Fig.19- Horizontal section of the olfactory lamella of *Catla catla* throwgh the supporting zone of the mucosa X1000

Fig.20- Horizontal section of the olfactory lamella of *Catla catla* through the mucosal region to show the transformation of basal cells X1000

B.C.	:	basal cells
B.Z.	:	basal zone
CL.	:	cilia
C.S.C.	:	ciliated supporting cells
I.L.S.	:	interlamellar space
N.S.C.	:	non-ciliated supporting cells
R.R.	:	rod shaped receptors
S.R.	:	spindle shaped receptors
S.Z.	:	supporting zone
T.B.C.	:	transitionary basal cell

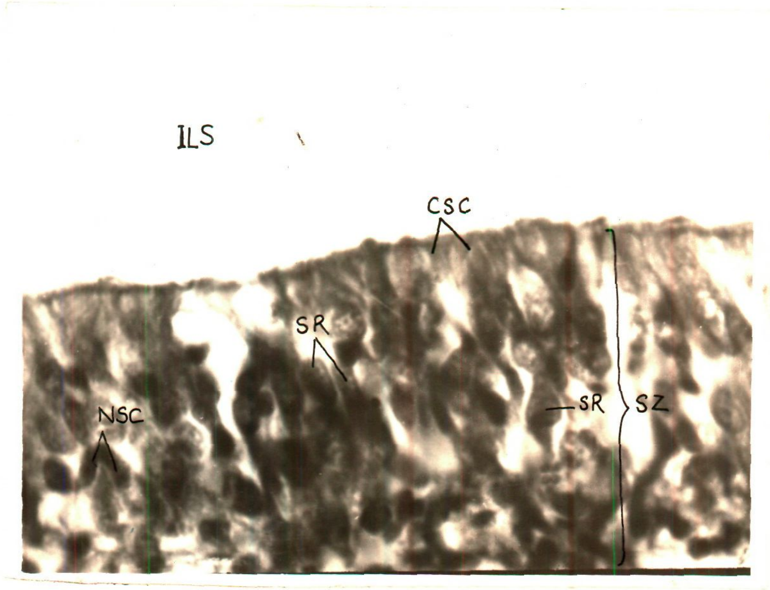


Fig.19

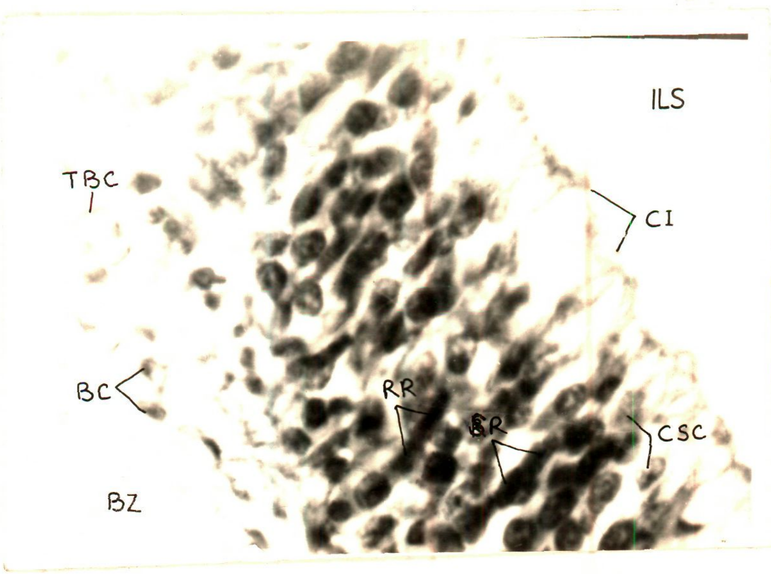


Fig. 20

Fig.21- Horizontal section of the olfactory lamella(*C.catla*) through the proximal end X1000

Fig.22- Horizontal section of the rosette of *Catla catla* through the proximal ends of lamellae X1000

B.C.	:	basal cells
G.C.	:	goblet cells
I.L.S.	:	interlamellar space
R.R.	:	rod shaped receptor
S.C.	:	supporting cell
T.S.C.	:	transitionary supporting cell
N.G.C.	:	nucleus of goblet cell

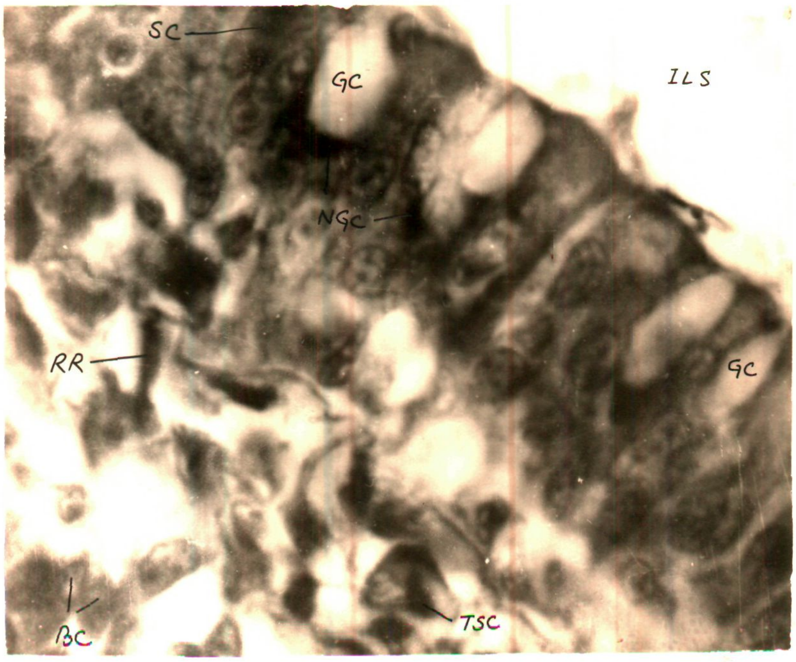


Fig. 21

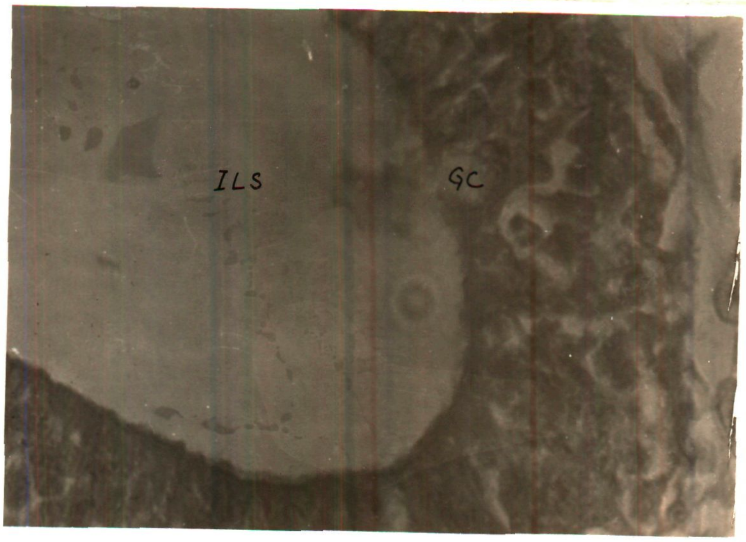


Fig. 22

B-1. Morphology of the nasal organs of *Clarias batrachus*:

a) The nasal chamber and its openings:-

In *Clarias batrachus*, the nasal organ consists of a pair of nasal chambers situated dorso-laterally in the anterior region of the snout (Figs. 23, 29, 30). Snout is short, dorso-ventrally flattened and bears four pairs of barbels, the maxillary pair being the stoutest (Figs. 23, 28, 29). The nasal chamber extends from a little behind the nasal barbel upto the anterior part of the snout. Each chamber communicates with the outside through a pair of an anterior and a posterior nasal opening (Figs. 24, 30). The former is a round opening borne on a forwardly directed nasal tube (Fig. 24). The posterior nasal opening is oval in shape and lies on the surface of the snout at a distance from the former. The posterior opening is guarded by a valve which is formed by an extension arising from the lateral sides of the opening. These projections partly overlap each other along the sides leaving a spindle-shaped narrow gap over the posterior nasal opening. The anterior nasal tube and the posterior nasal opening stand out sharply from the surrounding region of the snout by the colour contrast due to the snout being darkly pigmented while the former two structures are relatively devoid of the pigmentation.

b) <u>The nasal capsule</u> :-

Each nasal chamber lies in a fossa of the ethmoid complex and remains attached to the surrounding cranial bones by fibrous connective tissue. An oblong nasal bone shields the dorsal surface of the nasal chamber. The nasal itself joins the ethmoid laterally and gets support of the lateral ethmoid ventrally. The nasal chamber is surrounded on the lateral sides by palatine, maxilla and prefrontal while at the anterior side it is supported by premaxilla and a part of the ethmoid. The lateral ethmoid supports the chamber ventrally as well as posteriorly alongwith the frontal on the posterior side. A small foramen is present in the lateral ethmoid which allows the olfactory nerve to pass out of the bony capsule.

c) <u>The olfactory rosette</u> :-

Each nasal chamber accommodates an elongated oblong rosette occupying its entire cavity (Figs. 25, 32, 33). The long axis of the rosette is obliquely placed in relation to the median axis of the fish body. The dorsal surface of the rosette is concave whereas the ventral side is convex.

A linear raphe placed dorsally along the median axis of the rosette divides it into two equal halves (Figs. 25, 32, 33).

A large number of olfactory lamellae are attached on the either side of the raphe by their proximal ends. The laterally flattened olfactory lamellae are crescent-shaped and are closely set serially. Ventrally the lamellae are attached to the wall of the nasal chamber upto their distal ends. Dorsally each lamella bears a prominent linguiform process lying close to the distal end (Fig. 25, 32, 33). These linguiform processes in linear order form a ridge which demarcates the dorsal surface of the rosette into a central portion and a peripheral channel (Fig. 32).

The lamellae are of different size. The smallest lamella occurs at the anterior end and their size increases posteriorly suggesting their addition at the anterior end of the rosette. The attachment of the lamellae is perpendicular to the raphe in the two third of the rosette while in the posterior region they converge obliquely.

d) <u>The accessory nasal sac:</u>-

Close to the posterior extremity of the nasal chamber and ventro-laterally to the rosette lies an accessory nasal sac(Fig. 32). In a freshly killed specimen it appears like a distended oblong pouch with thin smooth walls. It opens into the chamber through an independent aperture just below the posterior nasal opening. In specimens preserved in Bouin's fluid, this sac appears collapsed with irregularly folded walls.

e) The anatomical relationship of the nasal organ and the brain:-

Dissection of the head exposes brain and its anatomical relationship with the olfactory rosettes(Figs. 27, 31). Both the chambers lie wide apart on either side of the ethmoid bone. Two prominent nerve bundles arise from the mesial side of each rosette which extend along the raphe. These fibres join to form olfactory nerve which passes through the olfactory foramen and lies between the rosette and the bulb. The bulbs are round and pedunculate structures situated close to the olfactory rosette. They are attached to the forebrain by long and narrow olfactory tracts. The olfactory lobes are moderately developed and are placed close to each other laterally.

f) <u>The ecological coefficient</u> :-

The two faculties viz. optic and olfactory were calculated by measuring the retinal and olfactory areas. and the ecological coefficient was found out. On an average the total surface area of both the rosettes came to be about 1050.12% of surface area of the two retinae of the fish.

FIGURES (B-1)

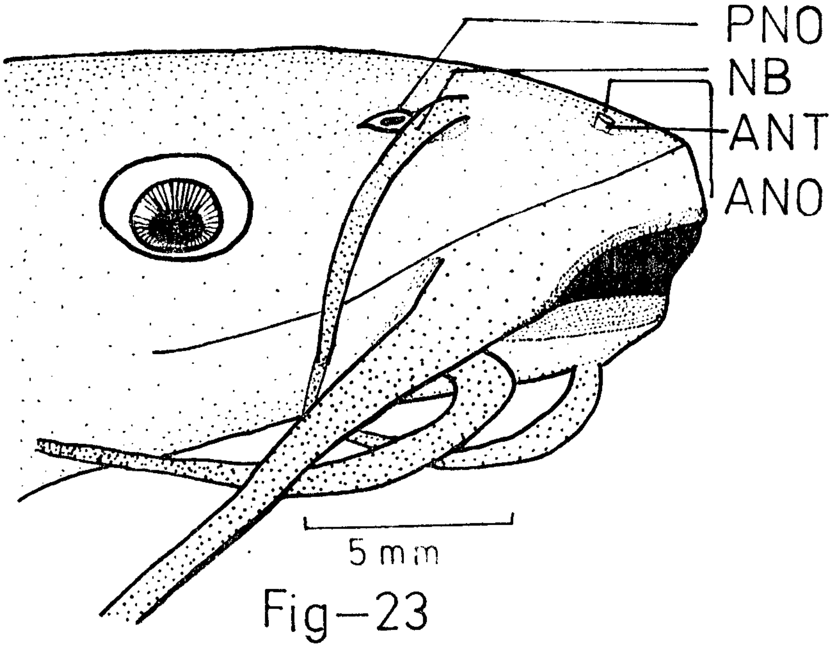
Fig.23- Lateral view of the head of <u>Clarias</u> batrachus

Fig.24- The two nasal openings of <u>Clarias</u> <u>batrachus</u>

Fig.25- The olfactory rosette of <u>Clarias</u> <u>batrachus</u>

Fig.26- A set of lamellae from right half of the righ rosette

A.N.O.	: anterior nasal opening
A.N.T.	: anterior nasal tube
C.P.	: central part
Lng.	linguiform processes
N.B.	: nasal barbel
Per.C.	: peripheral channel
P.N.O.	: posterior nasal opening
Rph.	: raphe
W.N.Ch.	: wall of the nasal chamber



Fig—23

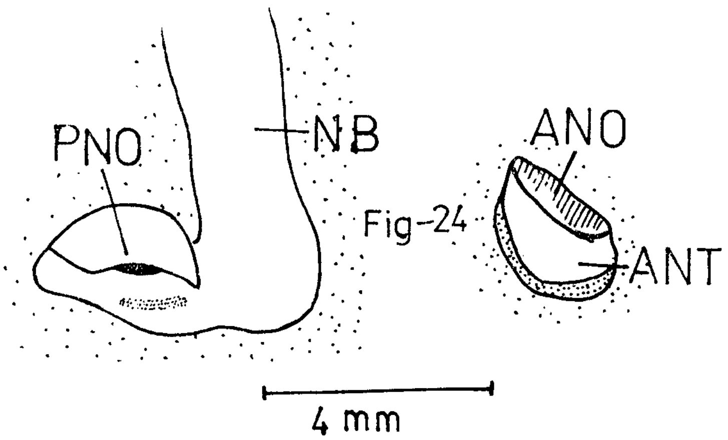


Fig-24

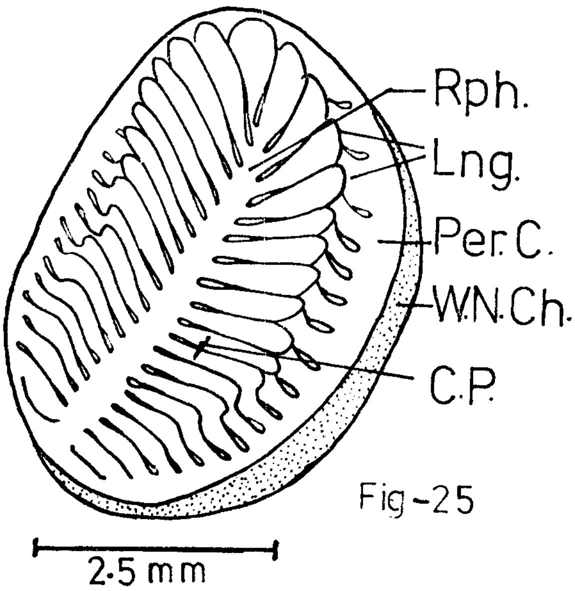


Fig-25

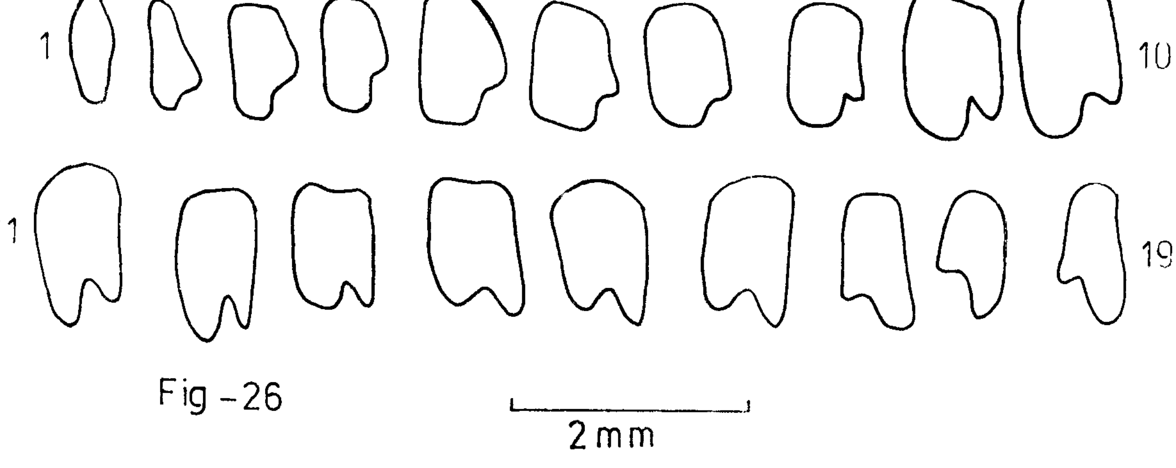


Fig -26

Fig.27- Dorsal view of the dissected head of *Clarias batrachus* to show nasal organs and their anatomical connection with the brain

A.N.S.	:	accessory nasal sac
Cbl.	:	cerebellum
O.B.	:	olfactory bulb
O.L.	:	olfactory lobe
Op.L.	:	optic lobe
O.T.	:	olfactory tract

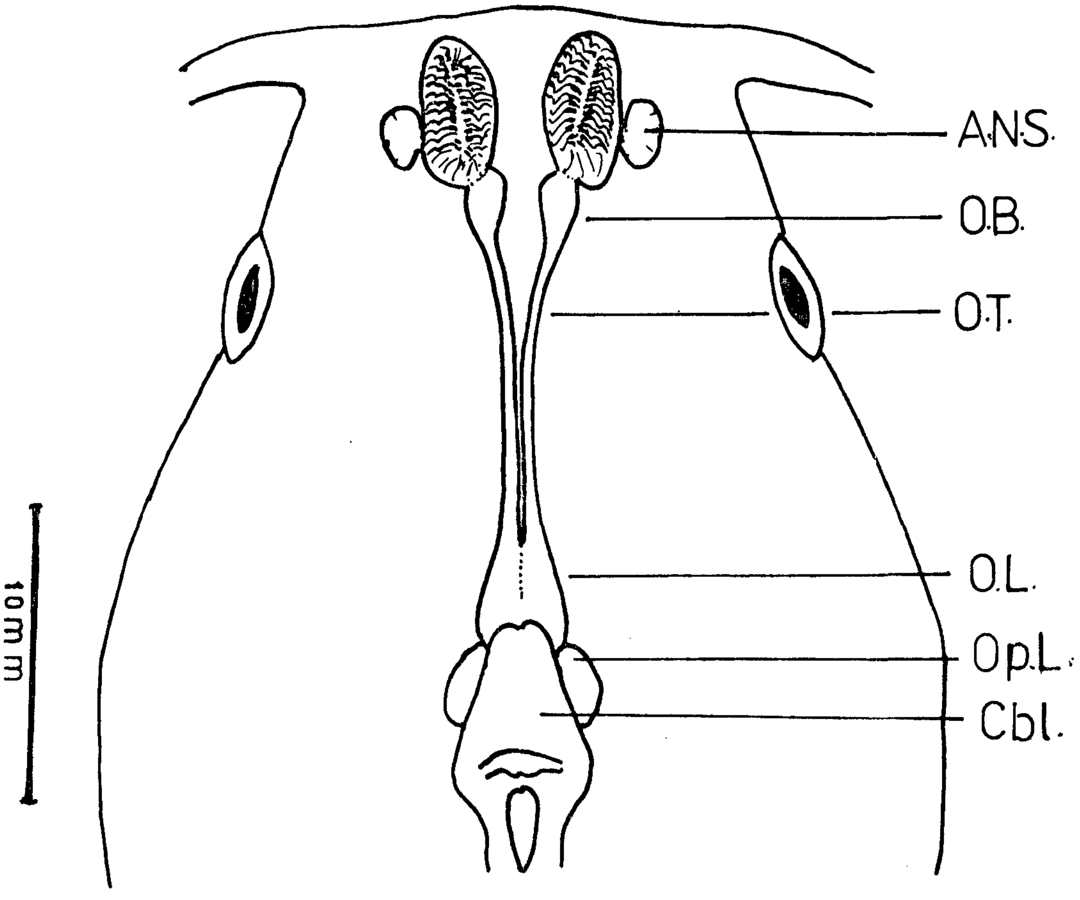


Fig. -27

Fig.28- Lateral view of <u>Clarias batrachus</u>.

Fig.29- Dorsolateral view of the head of <u>Clarias batrachus</u>

A.n.O.	:	anterior nasal opening
A.n.T.	:	anterior nasal tube
E.	:	eye
M.Br.	:	maxillary barbel
N.Br.	:	nasal barbel
P.n.O.	:	posterior nasal opening

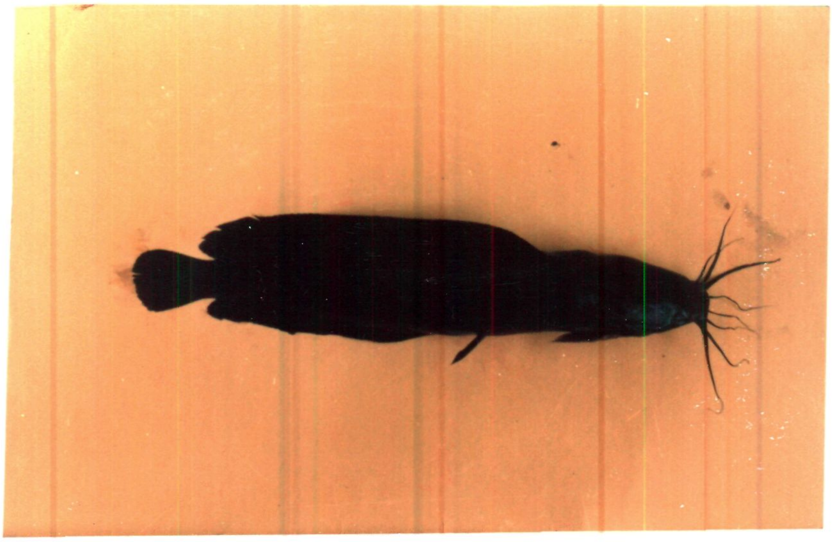


Fig. 28

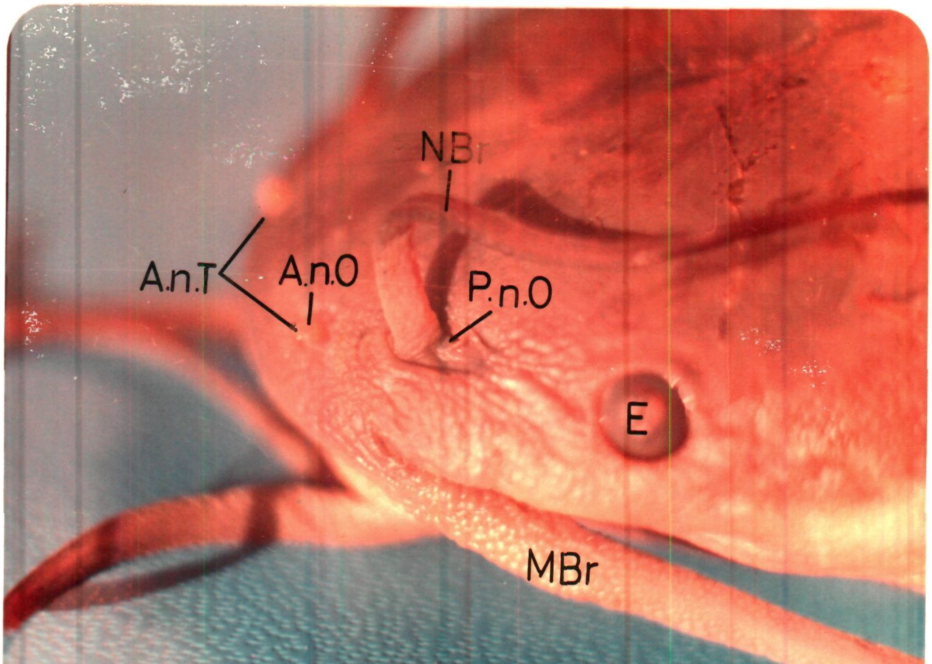


Fig. 29

Fig.30- Dorsal view of the anterior region of the head of <u>Clarias batrachus</u>

A.n.O.	:	anterior nasal opening
A.n.T.	:	anterior nasal tube
N.Br.	:	nasal barbel
P.n.O.	:	posterior nasal opening

Fig.31- Dorsal view of the dissected head of <u>Clarias batrachus</u>

Clb.	:	cerebellum
E.	:	eye
O.B.	:	olfactory bulb
O.L.	:	olfactory lobe
Op.L.	:	optic lobe
O.T.	:	olfactory tract
Rst.	:	rosette

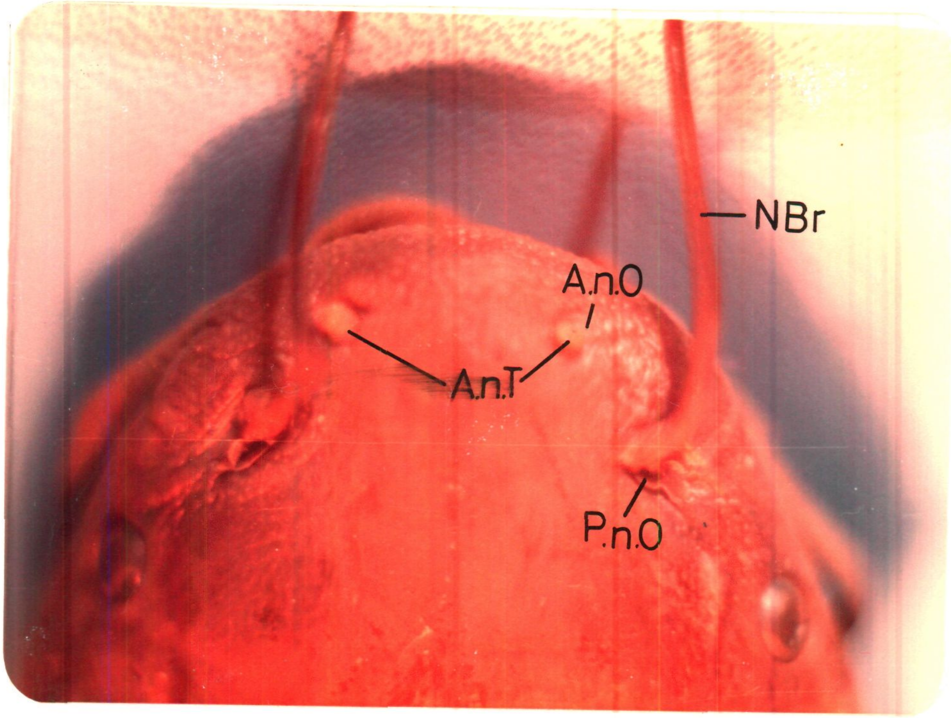


Fig. 30

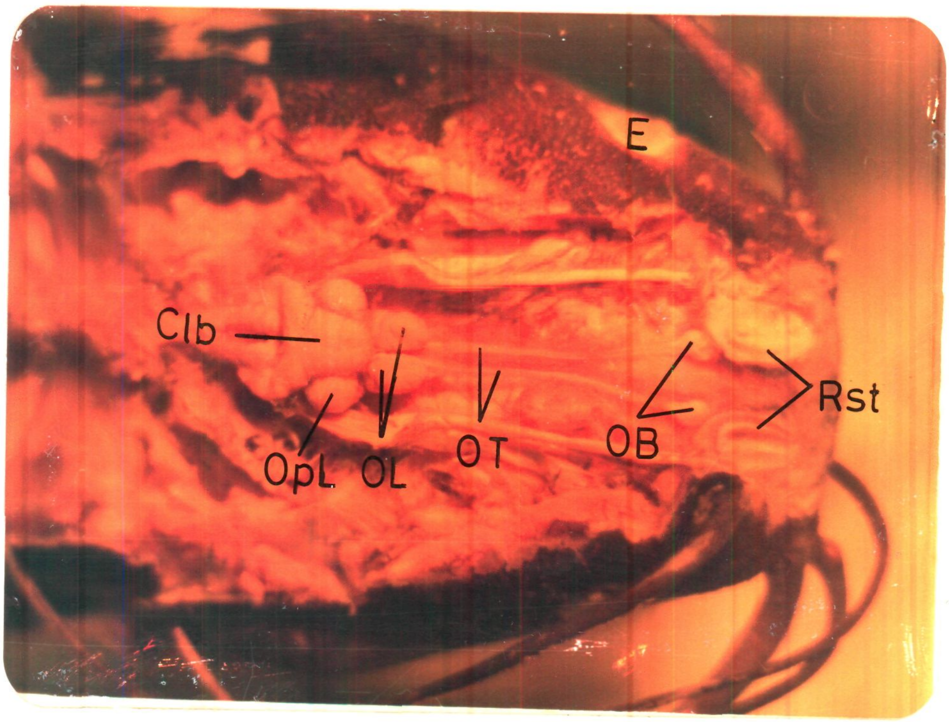


Fig. 31

Fig.32- Right anterior region of the dissected head of <u>Clarias batrachus</u>

A.N.S.	:	accessory nasal sac
C.P.	:	central part
Lm.	:	lamellae
O.B.	:	olfactory bulb
Lng.P.	:	linguiform process
O.T.	:	olfactory tract
Per.C.	:	peripheral channel
Rph.	:	raphe
W.N.Ch.	:	wall of the nasal chamber

Fig.33- Magnified olfactory rosette of <u>Clarias batrachus</u>

Lm.	:	lamellae
Lng.P.	:	linguiform process
Rph.	:	raphe
W.N.Ch.	:	wall of the nasal chamber

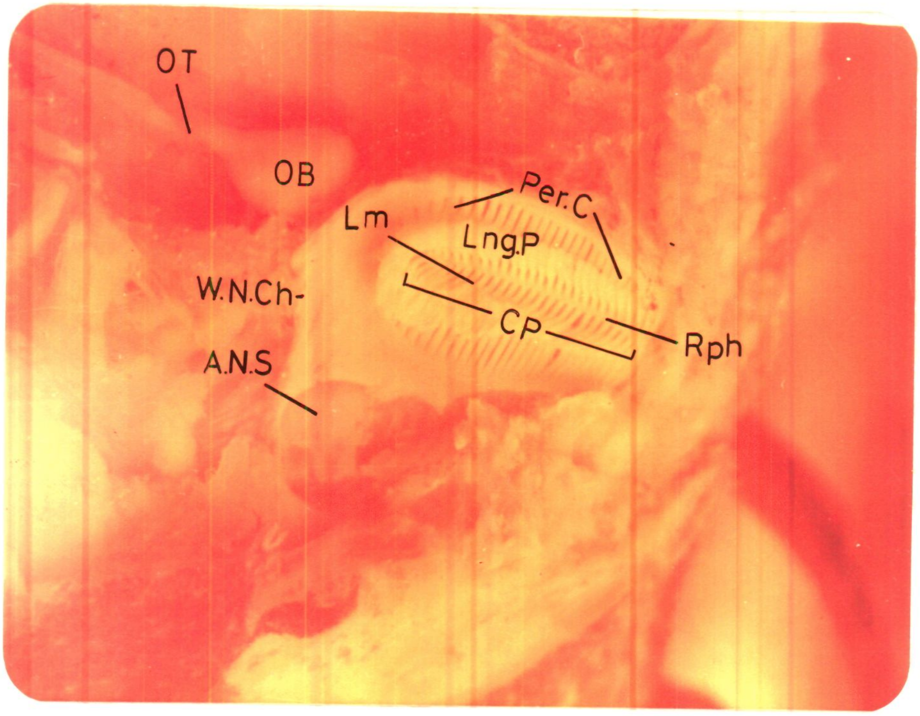


Fig. 32

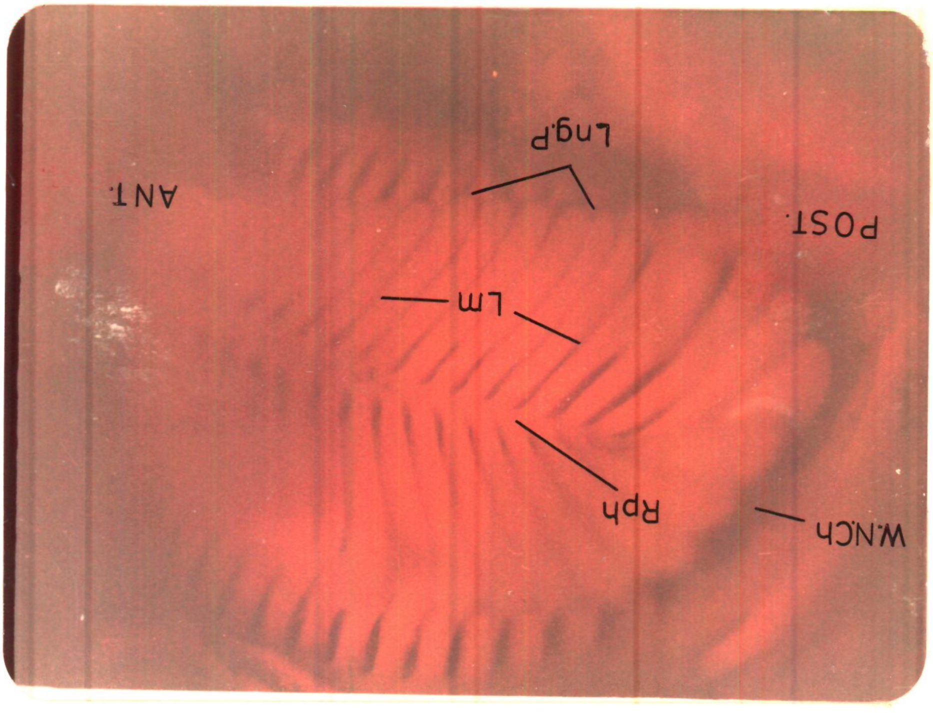


Fig. 33

B-2. Histology of the nasal epithelium of *Clarias batrachus*:

As stated earlier, the olfactory rosette of *Clarias batrachus* is composed of a set of lamellae attached to a median raphe (Fig. 34). These lamellae lie at equal distance from each other leaving an interlamellar space inbetween. Distally and ventrally they are joined to the wall of the nasal chamber (Figs. 34, 35, 36).

Both vertical and horizontal sections of the rosette reveal that in each lamella, there is a sub-mucosa forming a central core around which is a thick mucosal layer delimited from the former by a well defined delicate basal membrane all around (Figs. 34, 40, 41). The mucosa is a composite layer composed of following four cell types:

1. basal cells, 2. supporting cells, 3. receptor cells and 4. goblet cells.

The arrangement of these cells in the mucosa is such that two zones, the basal and supporting zones are clearly visible. The basal zone rests over the basal membrane and is composed of basal cells while the supporting zone is peripheral and contains other cell types (Figs. 37, 38, 40).

The basal zone:-

The basal zone is composed of cuboidal basal cells, arranged in continuous layers above the basal membrane (Figs. 35, 36, 42). At places the basal zone is interrupted by deeply embedded cell bodies of primary neurons and spindle-shaped receptors (Fig. 43). The nuclei of basal cells are rounded and stain darkly with haematoxylin. Some of the basal cells undergo muciparous activity and then through cyclic migration from basal zone to the supporting zone, give rise to mature goblet cells seen on the periphery. A few basal cells are also found scattered in the sub-mucosa (Figs. 36, 37, 38).

The supporting zone:-

The supporting zone comprises the following cell types:

a) supporting cells b) receptor cells and c) goblet cells.

a) The supporting cells:-

These cells are distributed in 2-4 tiers (Figs. 42, 43). The peripheral layer appears to be ciliated although the individual cilia are not visible (Figs. 35, 37, 38, 43). The cells of the lower tier are not ciliated (Figs. 42, 43). The supporting cells are densely packed.

The distribution of ciliated columnar supporting cells is uneven (Figs. 40, 41). They are broader at the distal end and extend upto the surface of the lamellae with their cilia projecting into the interlamellar spaces (Figs. 42, 43). The cytoplasm of the distal end picks up relatively more stain than the narrow proximal end. The nuclei of these supporting cells are large and somewhat oval.

The non-ciliated columnar supporting cells are distributed irregularly through out the nasal epithelium. The distal end of these cells are larger than those of ciliated ones and may reach the periphery. The cytoplasm of these cells is more or less equally stained at both the ends. The nuclei of non-ciliated columnar supporting cells are oval in shape (Figs. 40, 41). In sections some cells appear to be in the process of transition giving rise to ciliated supporting cells or goblet cells if required (Figs. 43, 44).

b) <u>The receptor cells</u>:-

The morphological types of receptor cells are distinguishable into spindle-shaped receptor cells and some other less differentiated types probably representing primary neurons.

The spindle-shaped receptor cells are distributed irregularly in the nasal epithelium and contain darkly staining cellular contents (Figs. 39, 40, 44, 45). The nuclei of these cells are elongated and lie just above the basal zone. Distally these cells give rise to dendrites which extend as narrow processes towards the periphery and are believed to end in olfactory vesicles. In the present sections such vesicles are not distinct. The dendritic cytoplasm is deeply stained as compared to the axonic extensions which arise at proximal end of the receptor cells. In the present sectioned material though the groups of receptor cells are seen (Fig.44) and can be clearly distinguished from the adjoining cells by their smaller size and spindle-shaped form but the final axons are so delicate that it becomes histologically difficult to spot them out. Similar difficulty was encountered by Allison(1953) in his identification of axons in some vertebrates. The so-called olfactory nerve fascicle of Allison(1953) and filum olfactorium of Bertmar(1972) could not be made out distinctly in the lamellae of the fishes under investigation.

The undifferentiated cells among the supporting cells which have been designated here as primary neurons are distributed unevenly. Their nuclei are oval and lie at different levels like the nuclei of spindle-shaped receptors. Their dendrites are thick and short and extend upto the peripheral zone where they swell up to form what may be called olfactory vesicle.

Regarding the existance of filum olfactorium it may be said that a similar difficulty in identification was experienced as in case of spindle-shaped receptors. Cytoplasm of the dendrites is clear and well stained. The axons traverse through the mucosal region into the basal membrane. The length of axon and dendrites are variable depending on the level of the nuclei of these cells.

The proximal part of the lamellae is richly supplied with spindle-shaped recepters and rarely with the primary neurons. The receptors are concentrated in the middle and only sparsely distributed in other regions. The spindle--shaped receptors and the primay neurons appear to be independent as no synaptic connection could be observed between the two.

c) The goblet cells:-

Two types of goblet cells are encountered in the nasal mucosa of Clarias batrachus viz. marginal goblet cells and migratory goblet cells.

The marginal goblet cells are found at the free surface of the mucosa and are scattered among columnar supporting cells and dendrites of receptor cells. These cells are formed as a result of transformation of columnar supporting cells. During this transformation the nucleus is pushed into the basal part of the stalk of the cell where it is finally lodged(Figs. 40, 41, 46).

There are few goblet cells that are seen lying deep into mucosa. They show migratroy behaviour (Fig. 41). The migratory cells are oval whereas the marginal ones are rounded.

The sub-mucosa of the lamellae:-

The submucosa lies connected with the raphe and also with the wall of nasal chamber. It is delimited on either side by the basement membrane (Figs. 34, 35, 36). Sub-mucosa is composed of dense connective tissue which is believed to be cellageneous in oringin. A few basal cells are also found in the marginal area of the submucosa. At certain places in the connective tissue of submucosa are found areolae and the blood capillaries (Figs. 35, 42, 44).

<u>The raphe:-</u>

The raphe is a central axis of the rosette histologically has amost similar composition as that of the submucosa but is devoid of sensory elements and goblet cells. The connective tissue of the raphe prov ides rig idity to the lamellae.

FIGURES (B - 2)

Fig.34- Horizontal section of one half of the rosette of *Clarias batrachus* X25

Fig.35- Horizontal section of the olfactory rosette of *Clarias batrachus* through the distal end of a lamella X450

B.C.	: basal cells
B.Z.	: basal zone
CI.	: cilia
C.T.	: connective tissue
D.E.	: distal end of the lamellae
I.L.S.	: interlamellar spaces
Lm.	: lamellae
Mc.	: mucosa
N.S.C.	: non ciliated supporting cells
C.S.C.	: cilited supporting cells
P.E.	: proximal end of the lamellae
Rph.	: raphe
S.Mc.	: sub-mucosa
S.Z.	: supporting zone
W.N.C.	: wall of the nasal chamber

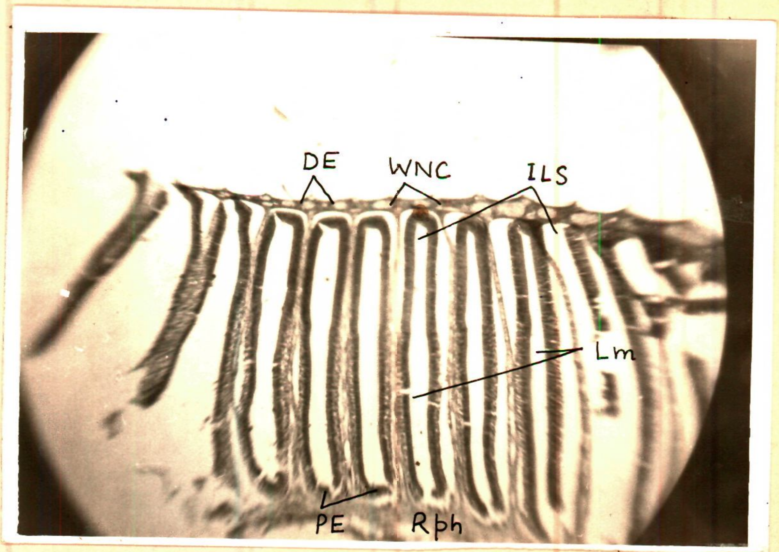


Fig. 34

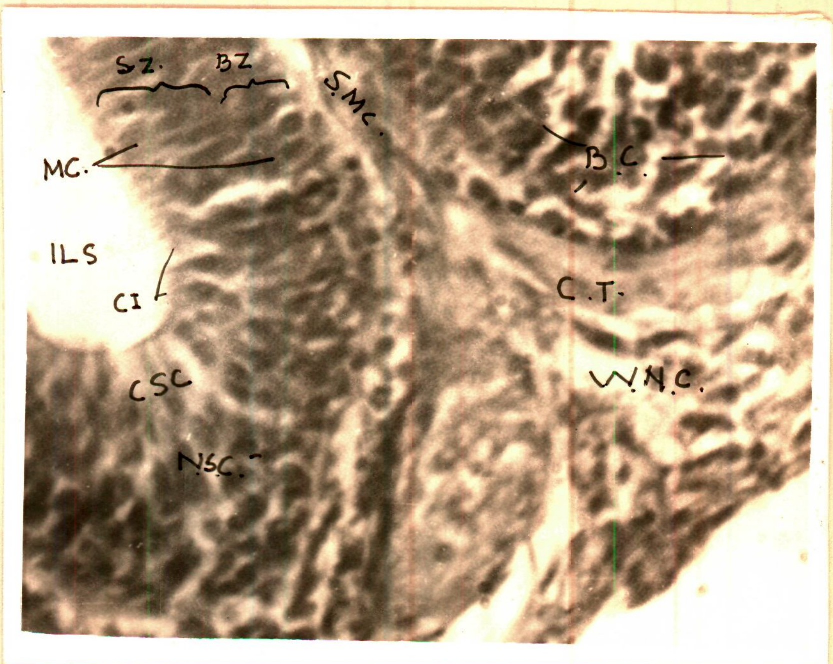


Fig. 35

Fig.36- Vertical section of the olfactory rosette of Clarias batrachus through the ventral region X450

Fig.37- Horizontal section of the olfactory rosette of Clarias batrachus through the proximal end of the lamella X450

B.C.	:	basal cells
BL.	:	blood capillary
B.M.	:	basal membrane
B.Z.	:	basal zone
CI.	:	cilia
C.S.C.	:	ciliated supporting cells
C.T.	:	connective tissue
F.N.C.	:	floor of the nasal chamber
I.L.S.	:	interlamellar space
Mc.	:	mucosa
N.S.C.	:	non-ciliated supporting cell
Rph.	:	raphe
S.C.	:	supporting cells
S.Mc.	:	sub mucosa
S.Z.	:	supporting zone

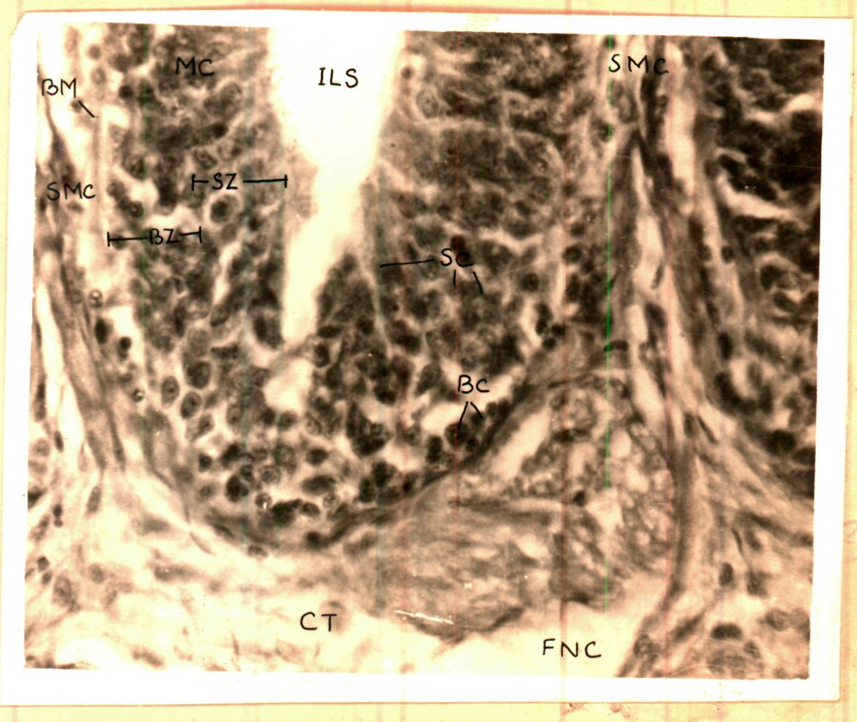

MC
ILS
SMC
BM
SMC
SZ
BZ
SC
Bc
CT
FNC

Fig. 36

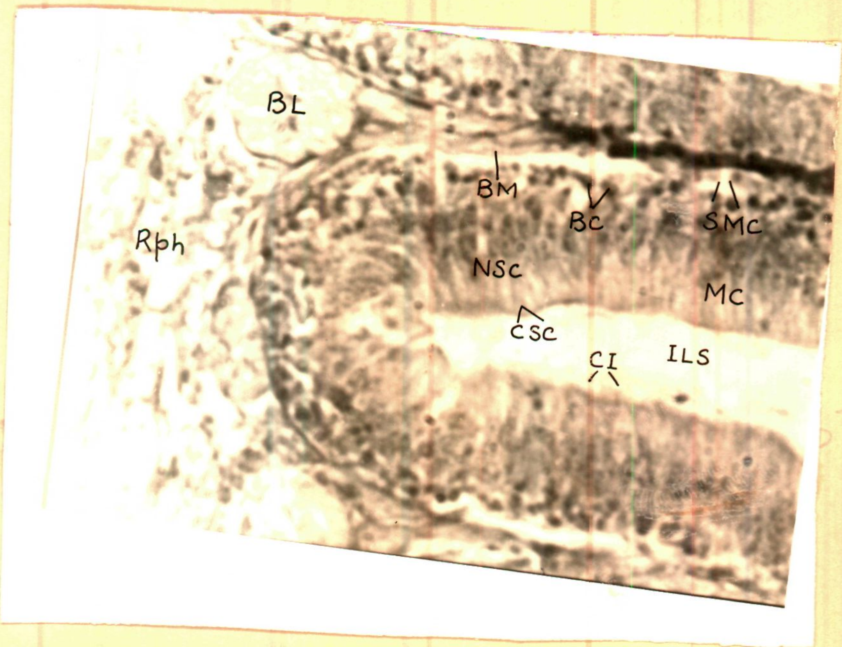

BL
Rph
BM
Bc
SMc
NSc
Mc
CSc
CI
ILS

Fig. 37

Fig.38- Vertical section of the olfactory lamella of _Clarias batrachus_ through the dorsal region X450

Fig.39- Vertical section of the olfactory lamella of of _C. batrachus_ through the dorsal tip X 1000

B.C.	:basal cells
B.M.	: basal membrane
F.C.	: fibrocyte
H.C.	: histocyte
N.S.C.	: non ciliated supporting cells
P.N.	: primary neuron
R.R.	: rod shaped receptors
S.R.	: spindle shaped receptors

Fig. 38

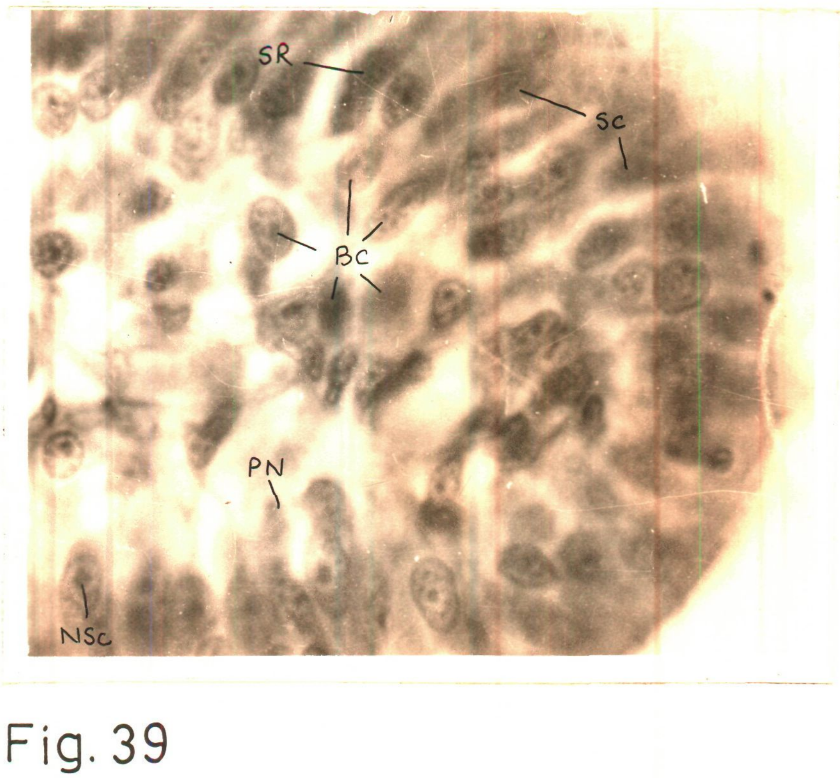


Fig. 39

Fig.40- Vertical section of the olfactory lamellae of *Clarias batrachus* through basal region X450

Fig.41- Vertical section of the olfactory lamella of *C.batrachus* through the middle region X450

B.C.	:	basal cells
B.M.	:	basal membrane
CI.	:	cilia
F.B.	:	fibroblast
G.C.	:	goblet cells
H.C.	:	histocyte
MG.C.	:	marginal goblet cells
N.G.C.	:	nucleus of goblet cells
P.N.	:	primary neurons
S.C.	:	supporting cells
S.Mc.	:	sub-mucosa

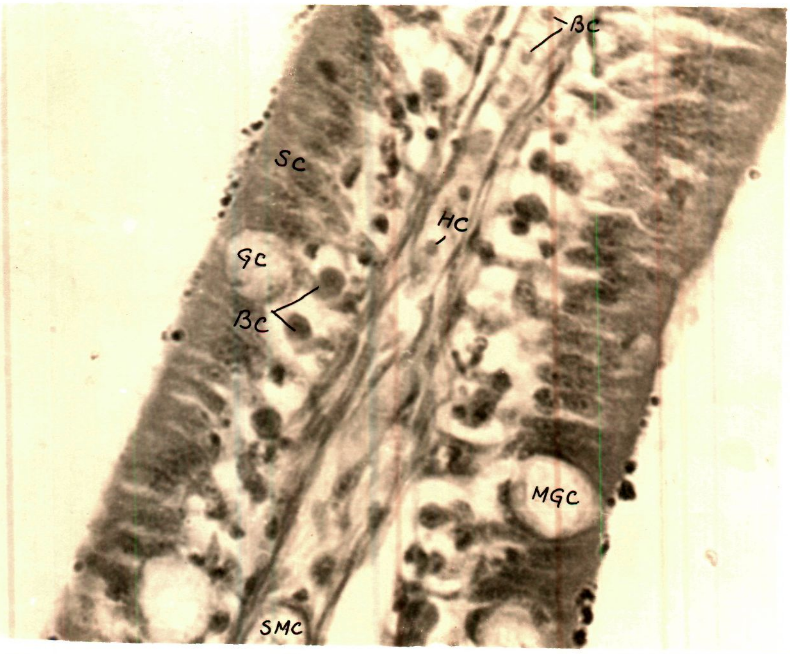


Fig. 40

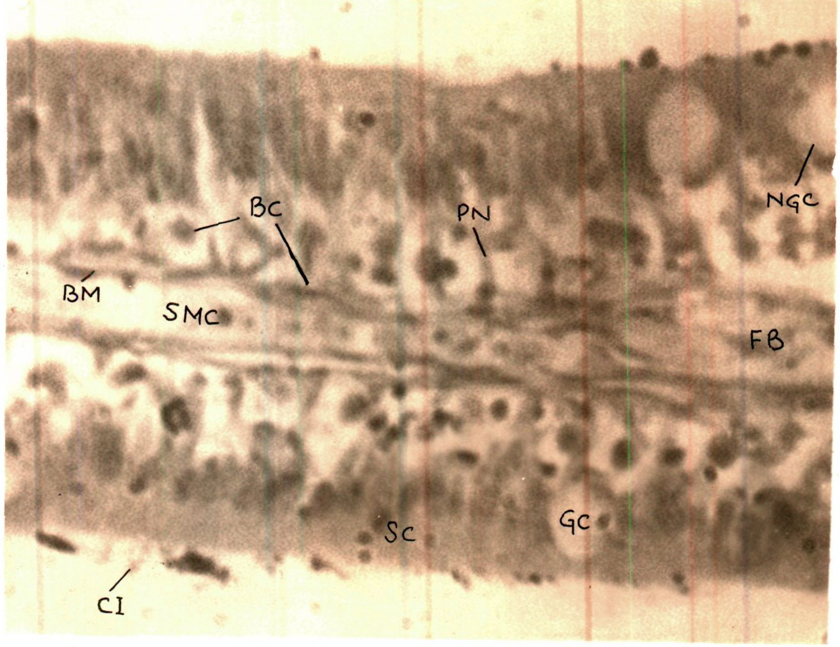


Fig. 41

Fig.42- Vertical section of the olfactory lamella of *Clarias batrachus* showing basal zone and sub mucosa X1000

Fig.43- Horizontal section of olfactory lamella of *Clarias batrachus* the mucosa with different cell types X1000

B.C.	: basal cells
B.M.	: basal membrane
B.Z.	: basal zone
CI.	: cilia
C.S.C.	: ciliated supporting cells
C.T.	: connective tissue
H.C.	: histocyte
N.S.C.	: non-ciliated supporting cells
P.N.	: primary neuron
R.R.	: rod shaped receptor
S.Mc.	: submucosa
S.R.	: spindle shaped receptors
T.S.C.	: transitionary supporting cells

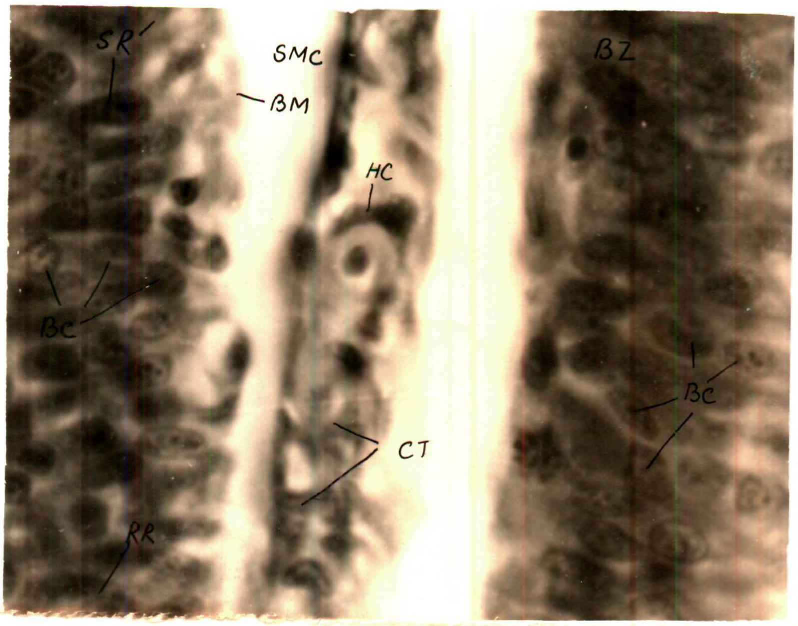


Fig. 42

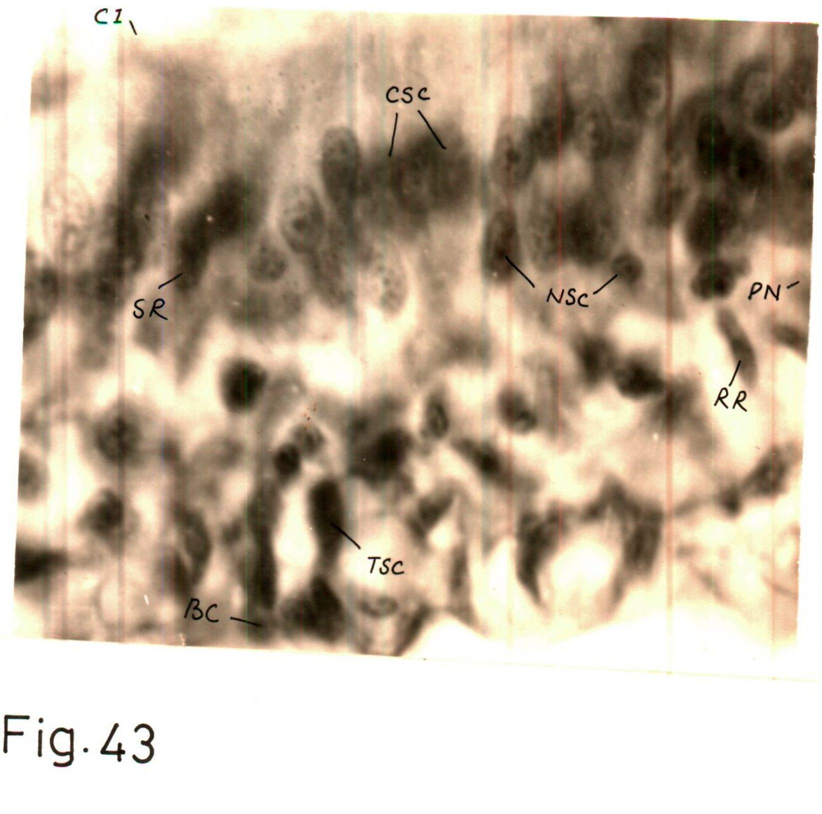


Fig. 43

Fig.44 and 45- Horizontal sections of the olfactory lamella of Clarias batrachus showing concentration of recepror cells X1000

B.C.	: basal cells
B.M.	: basal membrane
B.Z.	: basal zone
CI.	: cilia
C.S.C.	: ciliated supporting cells
F.C.	: fibrocyte
N.S.C.	: non ciliated supporting cells
P.N.	: primary neuron
R.R.	: rod shaped receptors
S.R.	: spindle shaped receptors
S.Z.	: supporting zone

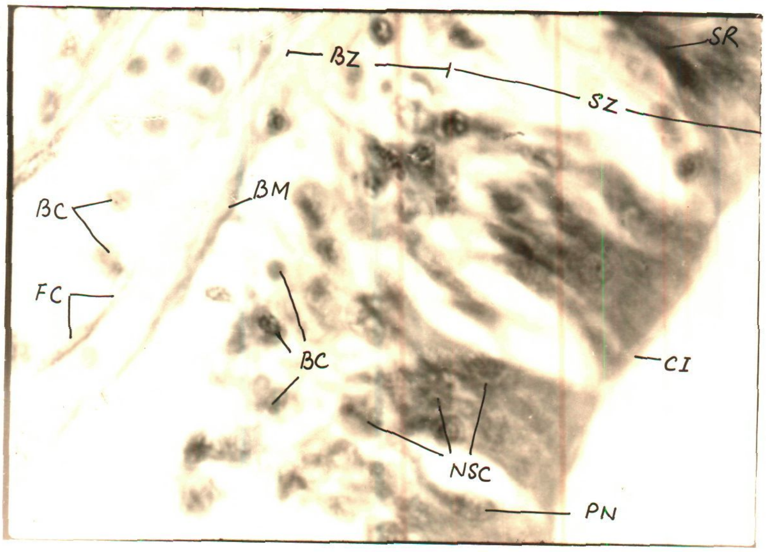


Fig. 44

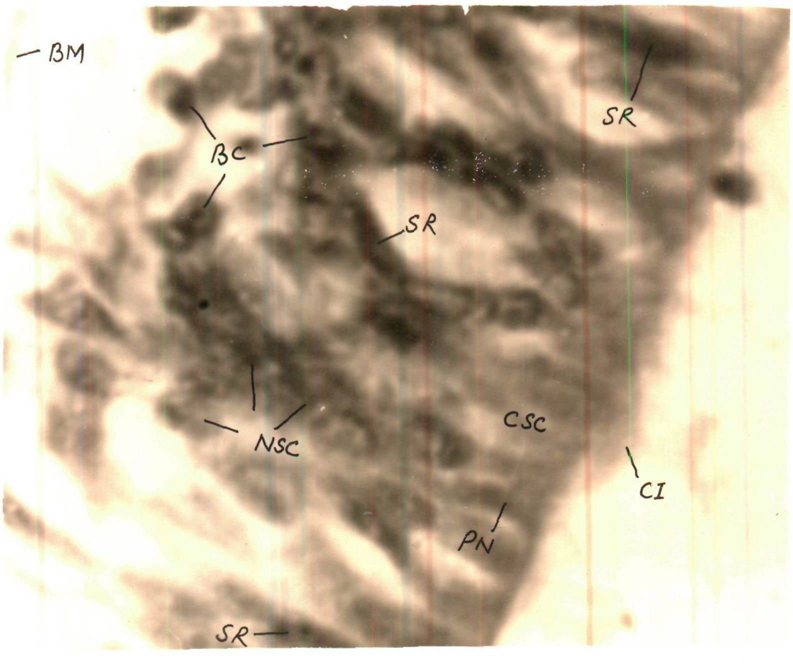


Fig. 45

Fig.46- Horizontal section of olfactory lamella of *Clarias batrachus* showing goblet cells X 1000

Fig.47- Horizontal section of olfactory lamellae through middle region showing some foregn particles entangled in the mucus of goblet cells X450

B.C.	:	basal cells
B.M.	:	basal membrane
B.Z.	:	basal zone
F.Bd.	:	foreign body
G.C.	:	goblet cells
I.L.S.	:	interlamellar spaces
M.G.C.	:	marginal goblet cells
S.C.	:	supporting cells
S.Mc.	:	sub-mucosa

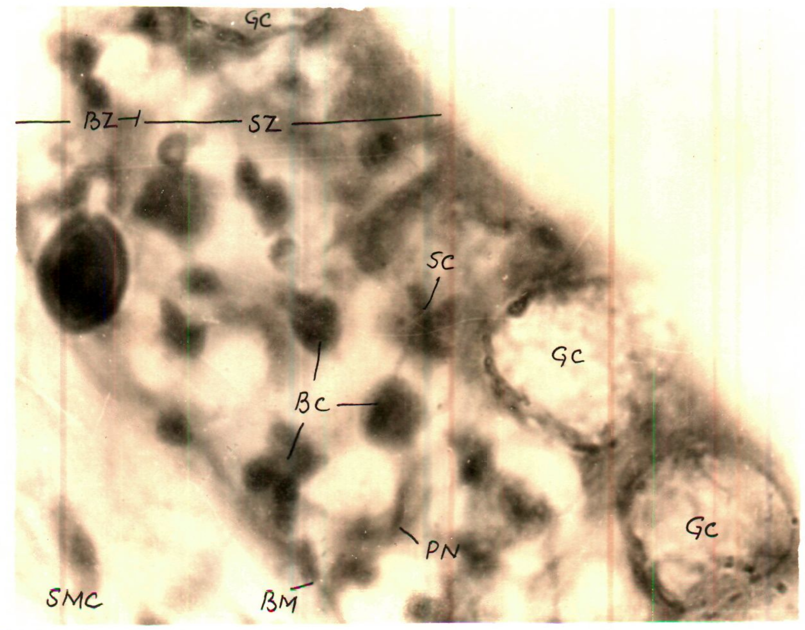


Fig. 46

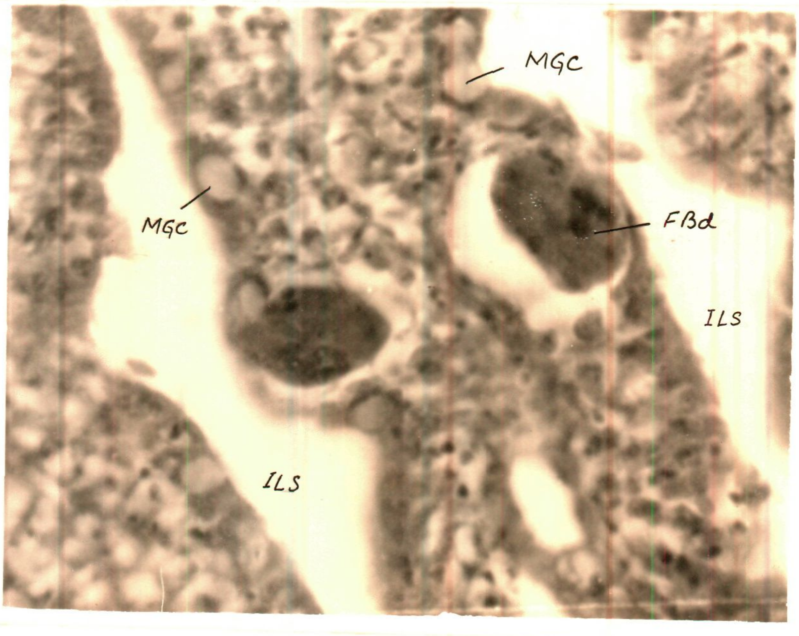


Fig. 47

D I S C U S S I O N

DISCUSSION

In teleosts a pair of nasal openings is present in each nasal chamber. They are usually situated on the dorsal side of the head and allow communication of the chamber with the exterior. There may be considerable variation in shape, size and location in different fishes. In some, the two openings are widely separated as in Silurus, Coregonus etc. (Burne, 1909) while in others they lie very close to each other e.g. Labeo, Cobitid (Burne, 1909).

Burne (1909) in his classical work on a number of fishes belonging to different families has shown that the anterior nostril very frequently forms a more or less tubular structure showing considerable variation in its extent. In some groups particularly of Cyprinidae and Gadidae, the hinder wall of the tube is raised to form a flap.

In some other groups this flap extends downwards and lies in the olfactory chamber above the centre of the rosette.

The posterior opening also shows variation in form. From a simple circular, oval or crescentic perforation or it may be slit-like closed with valve (Burne ,1909). The valved condition is usually found in fishes with accessory nasal sac which forms a part of the mechanism by which water is forcibly drawn into the chamber through the anterior nostril. The muscles that surround the sac allow alternate contraction and expansion synchronous with respiratory movements. According to Eaton(1956), these sac serve as mechanical device rather than an olfactory organ.because by their action, there is a constant stirring of water in the posterior region of the olfactory chamber which dislodge the debris which may accumulate in that part.

From the present study it appears that the two teleosts under investigation present a histological picture which could be considered of some consequence relative to some factors of ecology.

Clarias batrachus is a bottom dwelling fish which possesses a single accessory nasal sac in posterior part of the nasal chamber. It is a small strüture and occupies a position wherefrom it cannot be expected to forcefully draw in water through the anterior nasal opening. However, its movements may cause eddies which may help in dislodging the debris. In such forms where two sacs are present as in

Perciformes and Scleroparei (Burne, 1909), they can be consedered relatively more effective in drawing water current through the anterior nasal opening provided their alternate contraction and expantion are synchronous.

The nasal openings of the two fishes show different positions. In Clarias batrachus, they lie apart from each other in relation to the nasal chamber. In the former case, the anterior aperture is borne on a tube while in the latter it opens directly.

Again in Clarias batrachus, as has been mentioned already, the small anterior pore is borne on a tube leading into the nasal chamber and the posterior opening is slit like provided with a valve. Such an arrangement allows restricted water movements in and out of the nasal chamber. This is so because at the bottom where it lives, a lot of extraneous material which is found all around, cannot gain free access into the system. On the other hand in Catla catla, both the apertures are large enough and the presence of the hood and a curtain along the posterior margin of the anterior nasal aperture can allow free entry of clear water into the nasal chamber since the fish actively swims about in the surface zone. Apart from this, the curtain over the rosette in the absence of a valve prevents a rapid outflow of the water current through the open posterior aperture . So that the incoming water is subjected to thorouge analysis by the nasal epithelium. Kapoor and Ojha (1973 b) advocated that the presence of anterior nasal opening is characteristic of fishes with predominantly developed olfactory faculty (macrosmate). Kapoor and Ojha (1972 and 1973 b) reported that when anterior and posterior nasal openings are separated from each other by some distance the former is invariably borne on a tube. The shape and size of the olfactory rosette and number of lamellae is variable. Burne (1909) in his classical study on 51 genera belonging to 32 families has suggested a classification based on shape and size of olfactory rosette. The most commonly found rosette is oval in shape. Next in order comes the elongate one and the circular and round rosettes which are relatively rare. In some other forms a distinctive rosette is absent and in place exists a mushroom-shaped structure.

Burne (1909) has suggested a classification of rosette based on:

1) the general form and

2) the form of lamellae possessed by the fishes.

No. 1 above has been split up by the author taking four parameters into consideration, each representing a definite column in his chart as follows:

A- Rosette column I includes fishes with oval rosette and linear raphe,

B- Rosette column II elongated rosette,

C- Rosette column III circular rosette with a central stud or boss

D- Rosette column IV respresents rosette with longitudinal lamellae.

No. 2 contains three columns representing position and presence or absence of linguiform process in lamellae.

In his own studies Burne(1909) has assigned the fishes in these columns according to their characteristics. Apart from this, he also reviewd the Bateson's (1889)rose-tte types and has attempted to place his types in his(Burne's) own appropriate columns.

Teichmann(1954) based his findings on the efficiency and development of the visual and olfactory senses of several fishes and divided them into:

i) Eye-nose fishes - fishes with both faculties equally developed.

ii) Eye-fishes - Fishes with optical faculty more developed than the olfactory.

iii) Nose-fishes - Fishes with fairly dominant the olfactory faculty.

In order to determine the relative development of visual and olfactory senses, he employed another technique by measuring the retinal and olfactory area and calculated the ratio. These data are utilized for categorising fishes into microsmatic and macrosmatic, the eye-fishes are the nose-fishes respectively.

In the light of the observations made on the two fishes under investigation, the oval rosette of <u>Catla catla</u> finds a place in Burne's (1909) rosette column I (Beteson's (1889) rosette type 3) as regards the shape and in column II in respect of the position of the linguiform process. The elongated rosette of the other fish Clarias batrachus can be placed in rosette column II of Burne (1909) (Bateson's (1889) type 2 and taking into account the position of the linguiform process it can be placed in his column II.

Teichmann's (1954) method when applied to the present fishes it is found that the ecological coefficient of Catla catla with its oval rosette is suggestive of its being an eye- nose Teichmann's (1954) group I. Likewise the other fish Clarias batrachus, is classed as a nose-fish (Techmann's (1954) group III).

Rahmani and Khan (1981) contend that the olfactory area can not be accurately calculated in such fishes where villi-like secondary foldings occur in the lamellae resulting in the increase in surface area. In such case the values obtained can only be approximate. The present author while agreeing with this proposition feels inclined to suggest that there is yet another parameter which should not be lost sight of. It has been observed that regional concentration of the receptor cells in the epithelium plays an important role in olfaction and therefore should be taken into account for determining their functional efficiency.

Rahmani and Khan (1981) further suggested that a more reliable criterion can be length of the brain lobes viz. olfactory and optic lobes. To this it may be added that the length alone can not qualify as a reliable criterion because in fishes with elongated and laterally compressed heads, the length of the lobes may increase but the total volume may remain the same. It is, therefore, pertinent to suggest further that the volume of the brain lobe instead of length alone can hopefully provide more accurate information.

It may be recalled that Catla catla is devoid of an accessory nasal sac and is provided with a prominent layer of ciliated supporting cells bordering the mucosa with a few goblet cells. In Clarias batrachus on the other hand, this ciliated layer is interrupted by numerous goblet cells which are continuously replaced by a progressive transformation of the supporting cells. The goblet cells in Catla catla though present but never exceeds a certain limit and are no match for the numerical superiority of the cells in Clarias batrachus.

This contrast can easily be explained keeping in view the differences in the niche and the mode of feeding of the two fishes. The Clarias batrachus inhabiting the bottom needs larger quantities of mucus to trap foreign bodies which flow in through incurrent murky water.

The wall of the accessory sac is also studded with goblet cells. These in cojunction with these present in lamellar surface ensure cleansing of water for final analysis.

Doving et al. (1977) in their studies on several fishes have come to the conclusion that the fishes use either the ciliated cells for sampling water or use the pumping action of the accessory sac for this purpose. The findings of the present writer are in complete agreement with this point of view. Catla catla has a distinctive continuous layer of ciliated cells and provides a strong ciliary force for the transport of water within the chamber. It being a surface feeder draws in relatively clear water and does not have to face serious problem of extraneous particles hence it does not require larger quantities of mucus for this purpose.

The features of the two fishes as enumerated above are in conformity with the niche they inhabit. This opinion is reinforced by additional information provided by ecological coefficient.

SUMMARY

SUMMARY

Ecostructural studies of the nasal organs have been made in the two fishes, *Catla catla* (Hamilton) and *Clarias batrachus* (Linnaeus).

In *Catla catla*, the nasal chamber possesses an oval olfactory rosette inside and communicates with the exterior through a pair of openings devoid of valves. It also possesses a nasal hood and a curtain. The lamellae of the rosette have a uniform layer of ciliated cells with a few scattered goblet cells. The retinal and olfactory areas suggest the equal development of the visual and olfactory faculties thus the fish is an eye-nose fish.

Clarias batrachus on the other hand has an elongated olfactory rosette with a single accessory nasal sac. The anterior opening of the nasal chamber is borne on a tube and the posterior aperture is guarded by cutaneous folds which act as a valve. The ciliary lining of nasal epithelium is discontinuous and is studded with numerous goblet cells on the surface. Stages of transformation of goblet cells from basal cells are also visible. The large number of receptor cells and ecological coefficient is suggestive of its being a nose-fish.

In the discussion that follows , certain conclusions have been drawn keeping in view,the ecostructural peculiarities of two fishes . The text is illustrated with a number of figures and photomicrographs.

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